**PHENOTYPIC CHARACTERIZATION OF INDIGENOUS CHICKENS IN SELECTED STATES OF THE GUINEA SAVANNAH ZONE OF NIGERIA**

**By**

**OKOH, JOSEPH JOSEPH  
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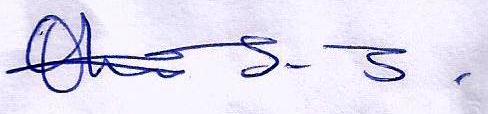
**DEPARTMENT OF ANIMAL PRODUCTION,**

**FACULTY OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY**

**FEBRUARY, 2018**

**DECLARATION**

I hereby declare that this dissertation was written by me and it is a record of my own research work. It has not been presented before in any previous application for a higher degree. References made to published literature have been duly acknowledged.

  
…………………………. Date…………………………..

**Okoh, Joseph Joseph**

The above declaration is confirmed.

…………………………… Date …………………………….

**Prof. S.T. Mbap**

Chairman, Supervisory Committee

**CERTIFICATION**

This dissertation entitled ”**Phenotypic Characterization of Indigenous Chickens In Selected States of the Guinea Savannah Zone of Nigeria”** meets the regulations governing the award of the degree of Doctor of Philosophy of AbubakarTafawa Balewa University, Bauchi**,** and is approved for its contribution to knowledge and literary presentation

…………………………… Date …………………………….

**Prof. S.T. Mbap**

Chairman, Supervisory Committee

…………………………… Date …………………………….

**Prof. T. Ibrahim**

Member, Supervisory Committee

…………………………… Date …………………………….

**Prof. Y.P. Mancha**

Member, Supervisory Committee

…………………………… Date …………………………….

**Prof. Y.P. Mancha**

Head of Department

Animal production

…………………………… Date …………………………….

Dean, Postgraduate School

**Prof. Y. D. Jiya**

**DEDICATION**

To my late father Mr. Abba L. Okoh and to the sweet memory of my mentor Prof. N.G. Ehiobu

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**ABSTRACT**

The study assessed the socio-economic and phenotypic characteristics of farmers and their indigenous chickens respectively in Benue, Kogi, Nasarawa, Niger and the Federal Capital Territory in Nigeria. Overall, 73% of farmers that kept indigenous chickens were females and 64.9% of the total had no formal education. Most chickens (51.8%) were raised extensively. Single comb 85.9%, brown plumage 19.81%, black shank 62.5%, black beak 60.0%, white skin 74.4%, red comb, ear lobe and eye colour 86.03% each and brown egg shell (58.99%) were commonest. Mean body weight was 1.88±0.01kg. Mean body length, width, shank, comb, wing and beak lengths, breast height and length were 19.36±0.02, 18.25±0.01, 9.39±0.03, 14.23±0.03, 3.12±0.01, 2.64±0.01, 11.60±0.03 and 18.05±0.01cm. The highest average egg weight (39.89 ±0.15g) was observed in Nasarawa, while the lowest (39.32±0.16g) was recorded in Kogi state. Benue and Nasarawa states recorded the highest and lowest average egg width, with respective values of 3.95 ± 0.02 and 3.8 ±0.02cm. Niger state recorded the highest average shell thickness (0.79±0.01mm), while Abuja had the highest albumen (4.62 ± 0.01cm). Haugh unit was considerably (67.450.11 -76.310.16) influenced by site. The highest clutch size of 13.11±0.23 was observed in chickens raised On-station and the lowest (10.84 ± 0.23) was in Abuja. Hatchability ranged from 94.81±0.45% for On- station birds to 99.12±0.43% in Nasarawa state. Newcastle disease was the most common (63.22%). Black/brown plumage with the highest body weight (2.01 ± 0.04kg) and black/white with haugh unit of (93.80 ± 0.01) could aid selection in weight and could improve the integrity of egg shells. Body and egg weights were correlated with all other measurements except in shell thickness and albumen weight which could be used to predict each other and to hasten selection. Poor housing, nutrition and sanitation were major challenges in indigenous chicken production. Improvement in management practices and vaccination against Newcastle disease should be adopted to curtail its devastating effect on indigenous chicken production.

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**CHAPTER ONE**

1. **INTRODUCTION**

**1.1 Background of the Study**

Prior to the 1930s poultry production in Nigeria was a sideline enterprise by, especially women who kept small flocks to provide extra income (Smith, 1990). Poultry production however has undergone rapid transformation since the 1940s when exotic breeds and intensive production were introduced (Permin and Pedersen, 2000). Poultry resources utilized during those early periods were indigenous un-improved species such as the domestic chickens (*Gallus* *gallus* *domestica*), guinea fowl (*Numida* *meleagris*), ducks (*Cairina* *spp*) which were restricted to the environment where they were found. Local avian / indigenous species are birds that have developed characteristics peculiar to a particular geographical location. Thus chickens which have adapted to the geography and environment of Nigeria are regarded as Indigenous Nigerian Chickens (Oluyemi *et al*., 1982). These birds are traditionally bred. Different bird species may be found intermingled. However, in most cases, chickens dominate and may make up 98% of the population (Gueye, 2003). Their distribution and density vary from place to place but are generally found in most areas suitable for human habitation. Rural poultry accounts for more than 60 percent of the total national poultry population and the indigenous chicken constitutes about 99 % of the total chicken population (Sonaiya, 1990).

Reports have also shown that 80% of Nigeria poultry are found in rural areas ( Fayeye *et al*., 2005; Gueye, 2005) and have contributed up to 90% of poultry products (Ibe, 1983). Another report showed that of about 192,640 tonnes of eggs produced in Nigeria in 1987, 24% was from indigenous hens of rural areas (Sonaiya, 1997). The International Food Policy Research Institute (IFPRI, 2000) estimated that by 2015 poultry should have accounted for 40% of all animal protein. Of course in Nigeria the bulk was still from indigenous poultry sources.

The Nigerian indigenous chicken which varies with location is generally characterized by several survival traits such as small body size, slow growth, hardiness, tolerance and/or resistance to diseases and parasites and, presence of major genes such as naked neck, frizzled feather, dwarfism etc. They are non- descript and vary widely in body conformation, plumage colour and other phenotypic characteristics. They reproduce earlier than most exotic chickens. Other unique attributes of the indigenous chickens egg have strong shell, good fertility, hatchability, high return to cost ratio and ability to provide cheap protein in quantities that are convenient for local use (Johnson, 1990). The indigenous chicken however has not attained its full potentials. This is due to exposure to several suboptimalconditions and risk such as presence of predators and parasites, diseases, poor feeding and other management conditions (Alemu and Tadelle, 1997). Teketel (1986) also reported that the productivity of the indigenous chicken in terms of meat and egg size is low.

* 1. **Statement of the Problem**

Improvement in productivity could be brought about through management changes including housing, nutrition and disease control. Genetic improvement which changes the inherent attributes should be a strong component in any productivity enhancement strategy. Crossbreeding as an improvement procedure has been introduced into the country. The most popular is the exotic cockerels cross breeding with indigenous birds in West Africa for body weight improvement. Apart from being prematurely introduced, the programme failed because of lack of improved husbandry technique and adequate follow up. Furthermore, the females of the crosses lacked maternal ability – incubation and brooding necessary for programme sustenance (FAO, 2004). The generally random crossbreeding and uncontrolled distribution of exotic breeds (in Nigeria) which is still being practised would also lead to indigenous chicken pool dilution. Indigenous chicken genotypes are also being eroded due to diseases, especially avian influenza, Newcastle etc. and predation. If this trend is allowed unabated, the indigenous chicken pool would be lost before it is properly studied and described. The FAO (1999) report also stated that animal genetic resources in developing countries, in general, are being eroded through rapid agricultural transformation. It further stated that the main cause of indigenous animal genetic resources (AnGRs) loss is the indiscriminate introduction of exotic genotype before proper characterization, utilization and conservation. Phenotypic and genetic characterizations are first step to sustainable improvement, utilization and conservation. On the onset it is important to know how unique different populations are, in certain environment (FAO, 2004).

Phenotypic characterization is usually carried out using visual observations and linear measurements. These classifications which have been generally known to vary with geographic location needed to be carried out all over and supported by genetic studies, which is very recent in Nigeria and involves to some extent the use of molecular methods, especially DNA markers, though not commonly available in the country.

* 1. **Aim and Objectives of the Study**

The objectives of the study are to:

1. Assess the socio - economic characteristics of indigenous chicken owners and management of stock in the study area
2. Phenotypically identify and classify the indigenous chicken.

Specific objectives include relating:

1. Some observable characteristics of the indigenous chickens to measureable attributes.
2. The effects of some known indigenous chickens’ major genes to productivity.
   1. **Justification**

Nigeria is endowed with numerous livestock species which are indigenous to the country. These animals have lived, reproduced and adapted to the environment for centuries (Nwosu, 1990). Most of the information on Nigerian indigenous chickens has been obtained from the southern states of Nigeria (Adebambo *et al.,* 1999). Recently, work on indigenous chickens has commenced in the northern states of Nigeria (Mbap and Zakar, 2000; Mancha, 2004; Momoh, 2005; Okoh and Momoh, 2008, Okoh *et al.,* 2009; Okoh *et al.,* 2010). Findings obtained in the southern part of Nigeria classify indigenous chickens into light ecotypes (Nwosu, 1979; Oluyemi; 1979; Nwosu and Asuquo, 1985; Nwosu and Omeje, 1984, 1985; Olori, 1994). In the northern states, information on the indigenous chickens kept by the Fulanis in the cattle kraals showed that they belong to the heavy ecotypes (Atteh, 1990; Mbap and Zakar, 2000; Mancha, 2004; Momoh, 2005). The North central agro-ecological zone presents a unique transition zone between the far North and South, hence, characterizing the indigenous chickens within this transition zone may result in further classifications which might differ from those earlier reported (Atteh, 1990; Adebambo *et al.,* 1999; Mbap and Zakar, 2000; Mancha, 2004; Momoh, 2005).

Furthermore, the paucity of information on indigenous chickens in Nigeria and their importance for meat and egg production necessitated proper study to provide further data which may be valuable as follows:

1. Available for the development of indigenous poultry industry in view of the recent ban on the importation of life and frozen poultry products into the country.
2. Use as baseline data for genetic improvement.
3. Assist indigenous chicken farmers to decide on the best management practices that will improve flock performance.
4. The result could be integrated as part of the global genetic / breeding and reproductive data for characterization, utilization, conservation and holistic improvement of indigenous chickens.

**CHAPTER TWO**

1. **LITERATURE REVIEW**

**2.1** Origin **of the Domestic Chickens**

The domestic chicken is believed to have descended from the wild Indian and Southeast Asian red jungle fowl (Zeuner, 1963). The evolutionary history of the domestic fowl can be divided into three phases. The first phase started with the evolution of the genus *Gallus*, followed by the emergence of the domestic fowl from its progenitors and then the appearance of the large number of the current breeds, varieties, strains and lines (West and Zhou, 1989). Domestication of the fowl in regions of the Indus valley is believed to have occurred by 2000 BC (Zeuner, 1963). More recent archaeological evidences however showed that a much earlier domestication occurred in China 6000 BC (West and Zhou, 1989). Four species of *Gallus* wereconsidered as progenitors of the domesticated fowl: *Gallus gallus* (Red jungle fowl), *Gallus lafayetti* (Ceylon jungle fowl), *Gallus sonnerrati* (Grey jungle fowl) and *Gallus varius* (Green jungle fowl) all are found in regions of Southeast Asia (Stevens, 1991). The monophyletic and polyphyletic theories however have contested the true origin of the domestic chickens. The monophyletic theory stated that the ancestor of the domestic chicken is the *Gallus* *gallus* while the polyphyletic had it that the ancestor is a combination of the different aforementioned wild species. Oluyemi and Roberts (1979) stated that the polyphyletic theory (Table 1) appears to be the most probable because it tends to support the many variations observed between and within breeds.

Table 1: Summary of the wild relatives of the domestic chicken

|  |  |  |  |
| --- | --- | --- | --- |
| ***S/No.*** | ***Name*** | ***Descriptions*** | ***Characteristics*** |
| 1 | *Gallus gallus,* *Gallus bankiya* or *Gallus ferruginous*( Red Jungle fowl) | North Central and Eastern India, Burma, Thailand, Cochina- China , Malaysia Peninsula, Philippines and Sumatra | Plumage of female resembles that of brown leghorn, males have orange red features in hackle, wingbow and saddle regions, while the breast is black, eggs are butts in colour, the legs are slate coloured. The comb is all red |
| 2 | *Gallus lafayetti*( Ceylonese Jungle fowls) | Sri- lanka | It is similar to *Gallus gallus* in plumages, but the males are orange on the breast and under parts, while the secondaries of the females are barred. The comb has yellow central parts surrounded by red and eggs are spotted. |
| 3 | *Gallus sonneratti*( Grey Jungle fowl) | South - West India | It carries the dominant silver genes which result in a white background in a place of golden one; upon which black patternses may be super imposed, eggs are sometimes spotted. The vocal utterances of *Gallus* *Lafayetti* are different from those of *Gallus* *gallus* |
| 4 | *Gallus varius, Galus fucatus* (Black or Grey Jungle fowl) | Java. Lombok | The neck features are short and rounded, the wattle is red yellow and blue green, the comb is green and reddish purple, male is predominantly green sheen(hence the name) |

**Source: Oluyemi and Roberts (1979).**

They further stated that the present day chicken resulted from inter breeding between several species of the wild birds which have developed due to mutation, selection (natural or artificial) and random drift. The red jungle fowl spread to Europe and was used for the game of cock fighting and religious rituals (Singh, 2000) up to the beginning of the 19th century. The utilization of poultry for meat and egg started during the 20th century when poultry husbandry developed into a commercial industry (Crawford, 1990).

The genome of the domestic chicken is 39 diploid chromosomes; eight pairs of macro chromosomes, one pair of sex chromosomes (Z and W) and 30 pairs of micro chromosomes. The size of the genome is estimated to be 1.2 X 109 bp (Olofsson and Bernardi, 1983; Groenen *et al.,* 2000). Chickens, like other avian species, differ from mammals in that the female is heterogametic (ZW) and the male homogametic (ZZ); the Z and W chromosomes displaying heteromorphism (Singh, 2000).

**2.2** **Overview of Indigenous Chicken Production in Nigeria**

Poultry are domesticated birds reared for meat and eggs. They include chickens, turkeys, ducks, geese, quails, guinea fowls etc. (Singh, 2000). Traditional poultry production existed even before the birth of Nigeria. It is widely believed that European missionaries imported the first exotic breeds. However, over the past few decades, many breeds, including the White leghorn (WLH), Rhode Island Red (RIR), New Hampshire and Cornish etc. have been introduced by different government and non-governmental organizations and/or institutions (Oluyemi and Roberts, 1979). However, despite the introduction of intensive production alongside modern strains for egg and broiler, up to 98.5 - 99.2 % of the national egg and poultry meat (AACMC,1984) are still obtained from indigenous chickens, with average annual output of 78, 000 and 72,300 metric tonnes respectively(ILCA, 1993).

***2.2.1 Challenges and opportunities of chicken production***

The continued downward trend in the economy of Nigeria does not favour poultry production using exotic breeds due to high input requirements and drain on foreign exchange reserves (Momoh, 2005). The author observed that the developments have made the indigenous poultry particularly the chicken more sought for. Over 80 percent of the Nigerian populace residing in rural villages and peri-urban settlements reared indigenous chickens through traditional production systems (Roberts, 1992); if properly assessed and selected may not only lead to genetic improvement, but may lay the foundation for the development of indigenous chicken breeds for both meat and egg (Gwaza *et al*., 2010). Jaap (1965) and Menzi (1965) have alerted the world that the poultry industry operates on a narrow genetic base that needs to be expanded to include the indigenous species as contributors of rare genes.

Indigenous chickens provide opportunities for increased protein production and income to smallholders (Sonaiya, 1997). Chickens have short generation interval (mature early), good mothering ability, and are affordable. They are also good scavengers and foragers, adapted to poor quality food and harsh conditions (Roberts, 1992).

The Nigerian indigenous chickens are said to be hardy and characterized by survival traits such as slow growth, small body size and tolerance to local diseases organisms and parasites (Momoh, 2005). They have high preponderance of major genes (e.g. naked neck, frizzle feather, silky feather etc.) with indirect effects on quantitative traits loci and direct relevance to production (Horst, 1997). He further observed that frequencies of these genes could be increased through selection and other appropriate breeding techniques, thereby increasing productivity.

The indigenous chickens possess the potential to grow fast at the early stages of life and therefore fitted for use as parents in broiler chicken development. Crosses with Arbor Acre broilers have shown that crossbreeding significantly improves meat performance (Nwosu, 1990). Substantial heterosis in body weight up to 20 weeks was achieved by crossing the indigenous chickens with parents stock of Gold link (Omeje and Nwosu, 1984). Nwosu (1990) concluded that the indigenous chicken combines significantly with exotic strains to achieve an improved 8th week body weight, which may become relevant in meat bird development.

Under improved conditions, Atteh (1990) reported that the indigenous chicken grew faster from 4 to 14 weeks of age than the popular White Leghorn. Oluyemi (1974) reported no significant difference in body weights of indigenous chickens and White Leghorn between 0 to 2 weeks of age. However, the indigenous chickens were significantly heavier between 4 to 14 weeks of age. The indigenous chicken is also regarded as a genetic raw material for layer production if appropriate genes can be transferred from the exotic breeds (Nwosu *et al*., 1979). Omeje and Nwosu (1984) had shown that the indigenous pullets produced first eggs at a significantly (P<0.01) earlier age than the Gold link stock. Improved body weight at point-of-lay which influences egg size and post-lay meat value has also been recorded at the 20th week (Nwosu, 1990). Indigenous chickens show good fertility and hatchability. Their eggs have strong shells and they also possess a variety of morphological and physical characteristics which are yet to be exploited (Ibe, 1990).

***2.2.2******Chicken management systems***

Poultry production in Nigeria is categorized into traditional, small and large-scale systems based on the objective of the producer, type of inputs, number and types of chickens kept (Alemu, 1995). Ibe (1983) also stated that rural domestic fowl production is largely based on indigenous chickens. They consist of small flocks of varying ages (AACMC, 1984). They are usually an integral part of the farming systems, a low input and output system used for various purposes (Smith, 1990).

***2.2.2.1 Extensive system of management***.

This is the traditional system practised all over rural, peri-urban and sometimes urban areas (Dafwang, 2002). At one extreme, chickens are left loose day and night on self supporting feeding without the provision of any form of housing( Hurchzermeyer, 1973) Chickens perch on trees at night, while majority sleep in bushes, exposed to harsh weather conditions and are extremely prone to predation and diseases (Aichi, 1995). However, sometimes, there are marked areas for birds at night but they are allowed to scavenge freely in the day (Kuit *et al.*, 1986). Supplementary feeding is usually allowed in the morning and evening (Dafwang, 2002). Another report (Aichi, 1995) showed that indigenous chickens under this system are basically left to scavenged feeds. However, occasionally, feeding may be supplemented with household refuse and grains. Any shelter is usually rudimentary (Hurchzermeyer, 1973; Atunbi and Sonaiya 1994; Kuit *et al.*, 1996; Yongolo, 1996) and varies with farming systems, such as pastoral, agro-pastoral and sedentary (Kuit *et al.*, 1985).

***2.2.2.2 Intensive system of management***

Intensive system involves continuous housing and feeding. Housing is more elaborate with adequate shelter, shade and pen space. Parasite problem is greatly reduced. Birds are maximally protected from harsh weather conditions and predation. This system is mostly used in commercial production. Building, equipments and feed cost are high (Smith, 2001). The system could be small or large scale. The large scale system may include rearing of birds in cages, automation of feeding and water supply and, feed mill operations (Aku *et al*., 2010).

***2.2.3******Diseases and******health care***

Diseases that affect the indigenous chickens include Newcastle, especially during the dry season, Coccidiosis and Fowl pox (Otchere *et al.*, 1989). Newathe and Larmode (1987) stated that Newcastle (ND) disease had remained prevalent because a large population of indigenous chickens, ducks and free flying birds had continued to maintain the virulent disease virus in circulation. In commercial poultry production, Coccidiosis, Marek (MD) and Infectious Bursal diseases (IBD) are more prevalent. Another report (Adene, 1996) stated that ND, IBD or Gumboro, MD, Fowl typhoid, Cholera, Mycoplasmosis and Coccidiosis are the major diseases that have been predominantly identified in commercial poultry in most African countries and together with chronic respiratory disease, nutritional deficiency and predation are the main causes of mortality (Ashenafi *et al*., 2004). In-view of the fact that poultry diseases are seasonal, occurring mostly during the dry season; traditional and small scale chicken owners are forced to sell and purchase them at lowest and highest prices during the beginning of the rainy and dry seasons respectively (Bourzat and Saunder,1990).

Worm infestation has also been reported (Tona, 1995; Chrysostome *et al*., 1995). High Helminth burden has been found in scavenging birds (Pandey *et al.*, 1993). Most indigenous chicken farmers do not have standard health care routines. However, adequate cleaning of poultry pens, regular disinfection and vaccination under intensive management are essential especially, vaccination against Newcastle disease, Gumboro and Fowl pox. At day old, Newcastle disease vaccine (NDV) is given intra ocular (I/O) and repeated two weeks later. Day 3-7 birds are vaccinated with Infectious Borsal disease vaccine in drinking water. Day 14-21, NDV is given intramuscular. Week 10-12 requires subcutaneous application of fowl pox; NDV is repeated at weeks 16-18 alongside IBDV. The NDV is again repeated during weeks 32-36 (Momoh, 2005). Coccidiostat and antibiotics are best administered in drinking water as prophylaxis against bacteria and protozoan diseases (Aichi, 1995).

***2.2.4 Mortality***

The Nigerian chicken production is characterized by high mortality caused by factors such as disease, predators, poor management and nutrition (Selam and Kelay, 2013). Okoh *et al.* (2009) reported native chick mortality of 56% in Benue. The authors attributed the mortality to incidences of Newcastle (60.34 %) and Coccidiosis (30.16%). Sergeyeva (1976), McNaughton *et al*. (1978) and Wyatt *et al*. (1985) found that mortality was higher among chicks hatched from eggs of lower weights. However, Vieira and Moran (1998) found 5% mortality at 49 days among chickens hatched from “heavy eggs”, while there was only 1.3% from “light eggs”. Deeming (1995) observed that percentage embryo mortality was higher in eggs weighing above 70g.

**2.3 Characterization of the Indigenous Chickens**

Characterization includes a clear definition of the attributes of an animal and the environment to which the populations is adapted, partially or not (FAO, 1984; Rege, 1992).It also includes population size, physical description, uses, prevalent breeding and production systems, population trends, and performance levels (reproductive, growth, meat and egg) (Weigend and Romanov, 2002). It is separated into two parts.

**a.** Phenotypic characterization is the process of identifying populations, describing their characteristics and those of the production environments. It is undertaken in two phases. The primary phase involves visits and interviews to identify the production environment.The advanced phase involve visits to measure physical adaptive and productive aspects (FAO, 2004).

**b**. Genetic characterization refers to the description of attributes that follow the Mendelian inheritance or specific DNA sequences (www.fao.org >biotech >doc> Vicente). The procedure uses molecular markers such as microsatellite or DNA markers (FAO, 2004). Microsatellites are simple sequence-stretches with a high degree of hyper-variability and are abundant and well distributed in eukaryotic genomes (Tautz, 1989; Cheng and Crittenden, 1994). The sequence consists of short segments of DNA with motif repeats of up to six base pairs (bp).

**2.3.1 *The typical indigenous chicken***

Hill and Modebe (1961), Nwosu and Omeje (1984) stated that the body of the indigenous chicken is small and compact. The feathers are fairly long and closely cover the body. The skin is pinkish white in colour. The back is straight and broad, being broadest towards the neck-shoulder region. The neck and back lengths on the average have been reported to be 10.37 ± 0.22cm and 17.87 ± 0.12cm respectively (Nwosu, 1990). The breast is narrow, shallow and oblong, the keel is meaty and sometimes tapers and is covered with feathers, but some are bare. The wings are short, thin and fleshed, not muscular, but closely folded and carried horizontally along the body, giving the bird an axial conformation, but sometimes sigmoid (Hill and Modebe, 1961). High proportion of meat has been reported in the indigenous chicken (Nwosu and Omeje, 1984). Hill (1954) attributed the good proportion of meat to back length, which is also associated with vigour

***2.3.2 Ecotypes***

Geographical isolation has resulted in body size differences in the Nigerian indigenous chickens. Body size (weight) has therefore been used to group them (Ohagenyi *et al*., 2011). Two main ecotypes have been identified (Atteh, 1990). The heavy ecotypes found mostly in the montane areas of southeastern, western, middle belt and northern Nigeria. The heavy ecotypes in the middle belt zone are locally called “Tiv” chickens (Gwaza, 2012). The light ecotypes are found in the swamp rainforest and derived savannah areas of southern Nigeria. There is also the Fulani ecotype chickens (Gwaza, 2012).

***2.3.3 The normal chickens and other variations due to major genes***

Apart from the indigenous chicken of normal size and feathering, there are other variations due to the activities of major genes (Ibe, 1990, 1993; Ikeobi *et al*., 1996) namely naked neck (Na), frizzle feathered (F), slow feathering (K) and silky feathering, soft feathering, non inhibitors (Id), fibro-melanosis (Fm), dwarfism (Dw), Pea comb(P), blue shell (O) (Horst,1989; Table 2 and 3).

***2.3.3.1 Dwarf gene***

The dwarf (Dw) gene results in 30 to 40 % reduction in adult body size and lead to speculation of inherent heat tolerance in broiler breeders (Horst, 1989). Heat tolerance of Dw genotype in laying hens seems uncertain (Decuypere *et al*., 1991). In fast growing chickens the Dw gene has no practical value for improving tolerance to chronic heat stress (Deeb and Cahaner, 2001). The dwarfing allele (dw and dwB) are involved in gene x genotype interactions with other gene (Merat and Bordas, 1974). The authors reported that they are controlled by several simple genetic factors which may be autosomic while others are sex-linked located on the Z chromosome. They stated further that normal females are always of genotype Dw/-, while dwarf females are always of genotype dw/-, because female is the heterogametic sex having only one Z chromosome and that females carrying a sex-linked gene of dwarfism are always pure and exhibit the trait. On the other hand, normal males may be homozygous Dw/Dw or heterozygous Dw/ dw, but dwarf males are always homozygous dw/dw. Double dose of dwarf causes the dwarfism to be much more evident in males than females (Merat *et al.,* 1974).

***2.3.3.2 Naked neck***

Naked neck in indigenous chickens is due to an autosomal incomplete dominant gene (Na) that causes absence of feathers on the neck and some parts of the body (Fraga *et al.,* 1989). Okpeku *et al*. (2003) stated that it is an unusual trait that is characterized by lack of feathers at the neck. The Na gene reduces the amount of feathers by about 20-30% in the homozygous (NaNa) genotype and up to 40% in the heterozygote (Nana) (Bordas *et al.,* 1978; Monnet *et al.,* 1979; Zein El Dein *et al.,* 1981; Rauen, 1985). In addition, the arterial tracts are wider in naked neck fowl (Hutt, 1949; Crawford, 1978). The heterozygous Na/na+ birds show isolated tuft of feathers on the ventral side of the neck above the crop, while Na/Na birds either lack this tuft or it is reduced to just a few pin feathers or small feathers (Crawford, 1976; Fraga *et al.,* 1989; Somes, 1990a; 1990b; Singh *et al.,* 2001). The feather tracks themselves are also either absent or reduced such that birds have greatly reduced feather cover. The capital tract of the head is absent (Somes, 1990b; Sonaiya, 2003). The contour feathers of the head, neck, trunk and limbs are restricted to more or less elongated narrow bands or clothed only with down feathers. The dorso – pelvic, dorsal caudal and pectoral tracts are all markedly reduced. The resulting bare skin becomes reddish, particularly in males as they approach sexual maturity (Somes, 1990b). The presence or absence of the tuft could be used to identify the two genotypes accurately at hatching (Crawford, 1976).

Low feathering has a slight positive maternal effect on early growth, especially when the Na allele is incorporated into the dam line (Merat, 1986). Low feathering intensity due to the naked neck genes enable the chickens which does not have sweat gland to improve thermoregulatory efficiency especially under heat stress by increased insensible heat loss via the uncovered body surfaces. The chickens therefore have greater flexibility in temperature regulation. They produced good egg shell quality due to high cholecalciferol synthesis from 7- dehydro-cholesterol 6 (Fraga *et al.,* 1989). Cahaner and Leestra (1992) reported a 3% weight gain at 20oC which triple at 32oC. Ajeng *et al. (*1993) found reduction of protein / energy requirements at high temperature with the decreased feathering and supportive structure. Yalcin *et al.* (1996) reported that body weight at 7 weeks was significantly affected by naked neck genotype. The advantages in body weight of naked neck over feathered birds were 3.4% for males and 2.8% for females. Feed intake improved and mean egg weights were heavier in both homozygous (NaNa) and heterozygous (Nana) fowl. Under hot climate condition naked neck showed better weight gain, higher productivity, better feed conversion ratio and lower mortality than the normally feathered (nana) (Merat *et al.,* 1974; Merat and Bordas 1974; Bordas *et al*., 1978; Merat, 1979; Monnet *et al.,* 1979; Zein El Dein, 1981; 1984; Bordas and Merat, 1984; Rauen, 1985). However naked neck and normally feathered birds of the same origin raised at temperature near 30oC or higher or 20oC or lower, did not differ significantly in growth rate and feed efficiency. At times, the naked necks were even inferior (Bordas *et al*., 1978; Monnet *et al*., 1979; Hanzi and Somes, 1983). Small body size has generally been associated with increased resistance to heat stress (Washburn *et al*., 1980). Similarly, the advantages of the naked neck gene with regard to heat stress vary with body weight (Washburn *et al*., 1980). It is therefore important to assess the importance of naked neck gene in both large and small bodied population in contrast to small body weight populations (Washburn *et al*., 1980). However, in general it has been concluded that productivity under hot environmental conditions could be improved through the introduction of the naked neck gene (Horst, 1988).

***2.3.3.3 Frizzle feathering***

Frizzling is a condition where recurving of the rachis and curling of the barbs are manifested (Somes, 1990b). Two genes have been found to cause frizzling in birds. They are the single autosomal incomplete dominant gene (F), and the modifier (mf) found in most non-frizzled fowls. The interaction of the genes produce varied phenotypic expressions of frizzling. The unmodified homozygotes (FF) exhibit extreme recurving of the rachis of all feathers curling of the barbs. These feathers are very narrow and break off easily such that birds are usually quite bare (Brush, 1972).

The mf gene modifies heterozygotes such that some birds are almost indistinguishable from the wild-type. Birds with frizzled feathers are nervous, broody, flighty and unattractive, but have normal body size (Okpeku *et al.,* 2003). It is common to find enlargement of the heart, spleen, gizzard and alimentary canal in frizzled birds due to increased food intake, oxygen consumption, heart rate and volume of circulating blood (Brush, 1972; Somes, 1990b). The beneficial effect of the F gene on growth at high temperature is less than that of naked neck alleles and the effect is only significant in slow growing line. However, there is additive effect in the double heterozygous (Na/na F/f) broilers (Yunis and Cahaner, 1999).

***2.3.3.4 Slow feathering gene***

The slow feathering (k) gene has been widely used to “auto sex” strain and breed crosses (Somes, 1990b). At hatch the primary and secondary feathers of the recessive (Kw or Kk) project well beyond the wing covers while those of slow feathering chicks (Kk or Kw) do not. They are two other alleles in series. Both dominant to the wild –type or K genes which is not used commercially (Somes, 1990b) Horst (1989) credited the K gene with indirect ability to reduce protein requirement, fat deposit in juveniles and increase heat loss during early growth, all of which assist the birds in resisting heat stress.

***2.3.3.5 Silky feathers***

Silkiness is a condition where feather shafts are more delicate with unusually long and frequently bifurcated (loose) barbs (Brush, 1972). The barbules are elongated, irregularly arranged, and lacking in both distal and proximal barbicels. Feathers generally lack the flat web form resulting in silky or wooly appearance (Somes, 1990b). Rectrices are much more affected than the remiges. The trait is determined by an autosomal recessive gene (h) (Brush, 1972). The gene may also improve the ability to dissipate heat (Horst, 1989).

***2.3.3.6 Other genes***

It has been suggested by Horst (1988; 1989) that several other genes may be useful in making fowl tolerant to tropical conditions. The dominant gene for pea comb (P) has been known to reduce feather tract widths, comb size and skin structures; this may improve the ability to dissipate heat. The author further reported that the recessive multiple linked allelic locus for dermal melanin may reduce radiation from the sun.

***2.3.4 The Head***

Nwosu and Omeje (1984) reported that the head of the indigenous Nigerian chicken is small, oblong and has vigorous appearance. The skull is curved and there is usually a tuft of feather on the head. The face is usually bright or smoky (Nwosu and Okoye, 1978).

***2.3.5 Comb and wattle variations***

Oluyemi and Roberts (1979) reported that the comb and wattles below the head are a modification of the skin peculiar to the avian. They added that the comb and wattles play an important role in sensible heat loss. The authors stated further that the male chicken has more prominent comb and wattles than the females as was also reported by Payne (1990) and Obioha (1992). Crawford (1990) reported six types of comb; single, rose, pea, walnut, butter-cup and V-shaped duplex. Ssewannyana *et al*. (2001) reported that the most frequent comb is the single and some hens do not have comb at all.

Table 2: Major genes in local fowl population with important effects on tropical oriented breeding

|  |  |  |  |
| --- | --- | --- | --- |
| ***Gene*** | ***Mode of Inheritance*** | ***Direct Effects*** | ***Indirect Effects*** |
| DW: Dwarf | Recessive, sex linked, Multiple allele | Reduction of body size between 30 and 10% from the normal | Reduced metabolism, Improved fitness. Disease tolerance |
| Na: Naked neck | Incomplete Dominance | Loss of neck feathers, reduction in pterylae width, reduction of secondary feathers | Improved ability for convection, reduced embryonic liveability(hatchability) improve adult fitness |
| F: Frizzle | Incomplete Dominance | Curling of feathers, reduced feathering | Decreased fitness under temperature conditions, improved ability for convection |
| K: Slow feathering | Dorminant, sex linked multiple alleles | Delay of feathering | Reduced protein requirement, reduced fat deposition(during juvenile life) increase heat loss during early growth, reduce adult viability |
| Id: Non inhibitors | Recessive, sex linked, Multiple alleles | Dermal melanin deposition  -skin  Shanks | Improved ability for radiation from shanks and skin |
| Fm: Fibromelanosis | Dominant with multi-factorial modifiers | Melanin deposition  -all over the body  -sheathes of muscle and nerve  - blood vessel walls | Protection of skin against UV radiation. Improved radiation from the skin, increased pack cell volume and plasma protein |
| P: Peacomb | Dominant | Change of skin structure, compact comb size, reduction of pterylae width, development of breast ridges | Decrease frequency of breast blisters, sex limited improvement of late juvenile |
| O: Blue shell | Dominant, sex linked | Deposition of blue pigmentation on egg shell | Improve egg shell stability |

**Source: Horst (1989)**

Table 3: Plumage variants in chickens

|  |  |  |  |
| --- | --- | --- | --- |
| **Traits and Gene symbol** | | **Traits and Gene symbol** | |
| **Variations in feather distribution** | | | |
| Naked neck | Na, na+ | Congenital baldness | ba, Ba+ |
| Aptery losis | Ap, ap+ | Edema | ed – 1, Ed – 1+; ed – 2, Ed – 2+ |
| Scaleless | sc, Sc+ | Ptilopody | Pti – 1, pti – 1+; Pti – 2+; pti – 3, Pti – 3+ |
| Ottawa naked | nk, Nk+ | Stubs | Ht; ht+; sb – 1,Sb – 1+; sb – 2+; Fsh+, fsh1 |
|  | Variations in feather length | | |
| Crest | Cr, cr+ | Eight tail feathers | ext, Ext+ |
| Muffs and beard | Mb, mb+ | Surplus primaries | Sf1, sf1+; Sf2, sf2+ |
| Vulture hocks | v, V+ | Long filoplumes | Lf, lf+ |
|  | Variations in feather structure | | |
| Feather structure | Ha, ha+ | Tail feather hypoplasia | Hy, hy+ |
| Frizzling | F, f+; mf, Mf+ | Matted down | \* |
| Silkiness | h, H+ | Ragged wing | rw, Rw+ |
| Naked wing patch | n, N+ | Porcupine | pc, Pc+ |
| Abnormal feathering | af, Af+ | Ropy | ropy, Ropy+ |
| Alopecia | \* | Stringy | st, St+ |
| Dysplastic remiges | dr, Dr+ | Stringy – 2 | st – 2, St – 2+ |
| Flightless | Fl, fl+ | Sunsuit | sn, Sn+ |
| Fray | fr, Fr+ | Wiry | wi, Wi+ |
| Henny feathering | Hf, hf+ | Woolly | wp, Wp+ |

\*Probably polygenic

**Source: Somes (1990b)**

Obioha (1992) and Smith (2001) stated that the comb types found in Nigeria are single, rose, walnut and pea. Mancha (2004) reported three comb types; single, rose and pea. Mancha (2004) and Ssewannyena *et al*. (2007) also reported that the red comb is the commonest among indigenous chicken ecotypes. Obioha (1992) reported that the indigenous tropical chickens and the Mediterranean breeds have more elaborate combs and wattles relative to body size in contrast to the temperate exotic ones, and that the appendages serve as thermo regulators. Van-kampen (1974) stated that this thermoregulatory role is vital in warm wet climate. Large combs therefore ensure survival and productivity of chickens in such climates. The size of the comb has also been shown to affect the frequency of agonistic behaviours in birds (Dawson and Siegal, 1962).

***2.3.5.1 Genetics of comb types***

The genetics of comb type is complex (Hutt, 1949). According to the author, all the comb types’- pea, walnut, rose, single and duplex are controlled by four pairs of genes; (RR, PP, rr, pp). Rose comb is RrpP or RRPP, pea (rrPP). He further stated that single comb type (rrpp) is recessive to rose and pea. Walnut (RrPp, RRPP) and duplex (dd) are recessive and the latter is controlled by gene modifiers (Plate 1).

* + - 1. ***Comb types***

1. ***Single***

The single comb consists of a blade which runs the length of the head and is topped by varying number of cusps. Five cusps per comb is the standard, but variations above and below this number are not uncommon (Malone, 1975). The size of the comb varies but it is more consistent within breeds (Smyth, 1970; Somes 1990b). Somes (1990b) stated that many single comb breeds particularly the heavy ones have relatively small sizes and that the Mediterranean breeds have larger sizes, while others have combs that loop over. The author reported that there are three major types of single comb, namely; spike blade; side sprigs and multiplex, and further stated that the spike blade is the normal and most common. It ends in a single spike instead of the usual broad oblong blade and is noticeable only at sexual maturity. The trait is recessive; with females better able to express it than males (Punnet, 1932; Buckland and Hawes, 1968; Lawrence 1963, 1968, Somes, 1990b).

The gene (sb) controls spike blade appearance (Somes 1990b). Side or lateral sprigs are frequent variants of single comb. They are extra spikes, one to three in number, which develop laterally from the posterior end of the single comb. They are usually noticeable in males by 3-4 weeks of age, but several months in female (Lawrence, 1963; Somes, 1990b). Crawford (1965) and Somes (1990b) also reported that the trait is not strictly due to a single gene but most probably multiple autosomal dominant complementary genes and the crest gene, Cr. They further stated that these genes in addition to some multiple factors result in multiplex comb with variations such as triplex, quadruplex and quintuplex. Quardruplex being most common.

***(b) Rose***

Rose comb is a characteristic of many chicken breeds (Crawford and Smyth, 1964; Crawford 1971; Somes, 1990b). The comb is broad, and nearly flat at the top, covered with small regular papillae, and ending with a spike or leader at the rear (Somes, 1990b). The length and width of the comb and, carriage of the leader depend on the breed. For most breeds the leader projects horizontally back from the head or tilts slightly upwards (Wehrhahn and Crawford, 1965). In others, the entire comb curves to conform to the shape of the skull. There are other variations such as downward pointing, hamburg, rugged, smooth and trifid rose combs. The downward pointing rose comb is dominant over the hamburg. Rugged and smooth rose combsinday-old chicks appear granular, while in adults it is bulky with higher and more numerous spikes. Trifid rose combs are characterized by triple spikes and tassel crests, with the middle spike being longer than the two outer ones (Crawford, 1965). Two varieties exist, water meal and silky. The silky rose comb is associated with a crest and is shorter in length with two or three points projecting from its posterior. The water meal comb however extends further backward and forms a point. RRpp or RrpP shows rose comb. In a cross between a homozygous rose combed RRpp chicken and a single-combed rrpp chicken; the F1 Rrpp will all have rose combs. The F2 will be 3 rose R-pp; 1 single rrpp. The recessive allele he1 produces a much smoother surface in both chicks and adults (Carvalie and Merat, 1965; Somes, 1990b). The homozygous smooth birds have fewer spikes than rugged birds. The water meal comb however is similar to the silky comb. It has been suggested that the crest gene is responsible for both the shortening and multiple points.

**(c) *Pea***

This is a characteristic of several breeds. It is sometimes called a triple comb. It is generally a low elliptical-shaped comb with three longitudinal rows of points running from front to back. The central row is the highest and most conspicuous (Somes, 1990b; Wright, 2009). The pea comb is controlled by an incomplete dominant autosomal gene (P). rrPP shows pea comb. If the heterozygous individual is paired with another heterozygous individual then the probality is that ¾ of the offspring will be pea combed and ¼ will be straight comb (pea + pea= pea; pea + straight = pea; straight + straight = straight)(Carvalie and Merat, 1965). The authors stated further that if one parent is heterozygous while the other is pure of the recessive gene, then the probality is that half of the offspring will be pea combed and the other half straight combed, the only time the recessive gene will manifest or appear is when it is paired with co-recessive gene, because of the absence of another gene that will dorminate it. Associated with Pea combs is a ridge of thickened skin that runs the length of the keel over the breast bone. This breast ridge is found only on birds carrying the P gene (Somes, 1990b).

**(d) *Walnut***

Walnut combs are smaller than either the rose or pea comb. Generally a shallow transverse groove separates the posterior part of the comb from the anterior portion (Carvalie and Merat, 1965; Somes, 1990a). This comb type results from the complementary interaction of the rose and pea comb genes (Punnet, 1932; Somes, 1990b). Crossing true-breeding rose RRpp and pea rrPP results in an F1 with all walnut combs RrPp and an F2 showing a ratio of 9 walnuts R-P-; 3 rose R-pp; 3 pea rrP-; 1 single rrpp (Somes, 1990b).

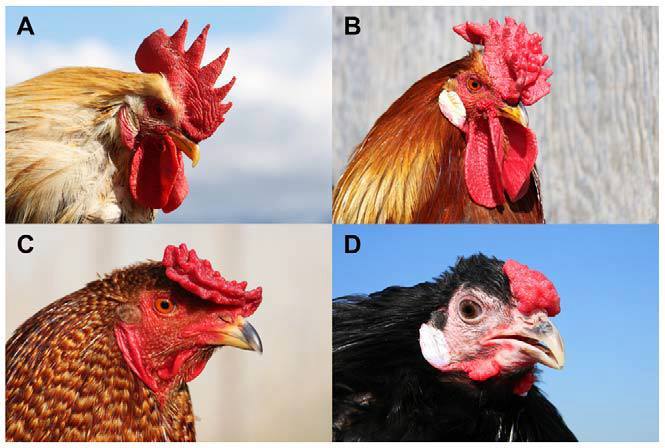
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Plate I: Four comb phenotypes in chickens explain segregation at the rose-comb and pea-comb loci and interaction. Single-combed wild-type male (rr pp), (B) Rose - combed male (R- pp), (C) Pea- combed male (rr P-) and (D) Walnut combed male (R- P-).

**Source: Imsland *et al.* (2012)**

**(e) *Duplex***

Duplex comb types include the Houdan leaf, Sicilian buttercup, and the V-shaped or horned. The leaf comb which resembles a butterfly with its wings partially open rests in front of the crest. The buttercup comb consists of a cup-shaped crown circled with medium-sized regular points and set on the centre of the skull. Other duplex combs are regarded as V-shaped since two spikes project from the base just above the beak (Kirby, 1994; Somes, 1990b). Most duplex combs, with the exception of buttercup, are associated with large cavernous nostrils. Somes (1990b) showed that the V-shaped and Buttercup combs are controlled by two different alleles located at a single locus. Duplex (dd) are recessive and controlled by gene modifiers (Hutt, 1949). The Dv allele, which is an autosomal incomplete dominant gene, is responsible for the expression of the V-shaped combs, while the Dc allele, an autosomal incompletely dominant gene controls the expression of buttercup combs. The Dv allele is dominant to the Dc allele. The characteristic wide cavernous nostril typical of short duplex-combed birds is expressed in birds homozygous for the Dv allele (Punnet, 1932; Somes, 1990b).

**(f) *Breda***

This is a combless condition. Females are completely combless while males show only two small papillae, one on each side of the centre line. This is accounted for by the presence of duplex gene (D). Comblessness is controlled by a single recessive gene. The dominant allele, Bd+ produces a normal comb (Somes, 1990a)

Some birds have functional double papillae, while others have definite clefts along the length of the papilla. The two properties are controlled by a single incomplete dominant gene U-2 and are closely linked to the rose comb locus. A third variant is the double oil gland (Somes, 1990b). The expression of this trait range from completely double glands to just a slight groove at the papilla tip. It is controlled by a single recessive autosomal gene (dgp), which has no association with the U locus of the rose-combed birds (Somes, 1980; 1990b).

***2.3.6 Plumage colour***

***2.3.6.1 Origin and melanization in the indigenous chicken***

Pigmentation in chickens is due to melanin (Marl and Brusbargh, 1971). The authors stated that the development of the melanin producing cells (Melanocytes) had been traced to the embryonic neural crest. They continued that with the exception of the retina, all melanin originated from the embryonic neural crest. The undifferentiated melanocyctes then migrates to other body tissues where they differentiate into pigment producing melanocytes (Melanosomes). These pigment producing granules are attached to the protein matrix of the pre-melanosome (Brumbargh *et al.,* 1973). These authors also reported that the golgi body associated tyrosine-tyrosinase pigment complexes and the structural protein of the melanosome involve different developmental processes each independently susceptible to mutational changes. Based on differences in colour, chemical composition, solubility properties and associated pigment granule structure, melanins are divided into two main types, eumelanin and pheomelanin (Smyth, 1990).

Melanocytes of the indigenous domestic chicken can produce either eumelanin (black) or pheomelanin (buff, red, and brown). Pheomelanin is found only in the feathers (Brumbargh, 1967). The author also noted that these pigments (eumelanin and pheomelanin) differ biochemically though they share the same synthetic pathway through the formation of dopaquinone. Brumbargh (1968) reported that in addition to the structural differences, each pigment is attached to a specific protein matrix that determines the different melanonsome sizes and shapes. Each basic pigment can be modified by genetic factors e.g. black to blue eumelanin by alteration of the structure of the premelanosome. The many phenotypic variations in pheomelanin are also the result of mutational changes in the melanosome concentration and distribution. The production of Eumelanin or pheomelanin depends on the genotype of the bird as well as its cyto-environment such as sex and feather tract specificities (Brumbaugh, 1967). Brumbaugh (1971) further reported that the major factor that determines coloured plumage pattern is eumelanin distribution and that pheomelanin formation is probably precluded in the melanocyte once black pigment is produced in response to the pigment cell characterized by cyto-environment stimuli. In line with the above Brumbaugh (1971) concluded that eumelanogenesis occurs at an earlier stage of development than pheomelanogenesis. He further suggested that interaction between genotype and environment takes place in the zone of differentiation of the developing feather. Red and yellow chicken feathers have also been shown to contain phenomelanin – related pigments called trichochromes (Smyth *et al.,* 1981). The main carotenoid of the chicken is the yellow fat – soluble pigment called xanthophyll (C40H56O2).  Xanthophyll is not synthesized by the fowl, unlike melanins; certain perceived colourations of the fowl are the result of structural variations in the surface of the keratinous feather, rather than due to pigmentation differences. The purple or green iridescent sheens of black feathers are due to the diffraction of light off the feather surface structure (Lucas and Stettenheim, 1972).

Kimball (1953) and Morejohn (1955) reported that eumelanin could be distributed on a zonal or regional bases, often involving one or several feathers traits **(**primary pattern); or it may be distributed within the individual feather (secondary pattern).

***2.3.6.1.1* *The Primary Patterns***

Smyth and Somes (1965), Smyth (1970), Carefoot (1981) and Smyth (1990) reported that the basic or zonal distribution of black melanin is determined by the E gene locus which is polyallelic, with at least eight alleles having an approximate order of dominace alleles as E > ER > ewh > e+ > eb > es > ebc > ey .

The E allele shows nearly complete dominance over all other alleles (Table 4). Modifying genes capable of enhancing or inhibiting the expression of eumelanin influenced the degree of dominance (Carefoot, 1981). These modifiers include Blue gene (BI), Lavender gene (Lav), Pink eye gene (pk). Red – splashed white gene (Pg), Sex – linked barring gene (B), Pea comb gene (P), Grey and erminette genes (Smyth, 1990). Other genes like Columbian gene (Co), Mahogany gene (Mh), Dark brown gene (Db) and Dilute gene (Di) affect (dilute) the distribution and expression of pheomelanin ( Campo and Orozco, 1984; Campo and Alvarez, 1988). Other genetic factors can cause enhanced feather eumelanization, in addition to the E and ER alleles and, thus play an important role in certain primary and secondary patterns. The melanotics, MI, Pg, Db and the P locus have been established (Moore and Smyth, 1971; Carefoot, 1981). MI is an incompletely dominant autosomal mutation that extends eumelanin into the normally red areas of pyle – zoned fowl, while having little effect on chick down colour. Heterozygotes on wild – type (e+) or brown (eb) backgrounds are distinctly darker, particularly in the hackle and head. However, MI/ml+ has little effect on ewh/ewh females. Homozygotes approach self – blackness, but the salmon pigment of the wild – type and wheaten females remain evident.

Three major gene loci (E, I and C) determine plumage colour, E and C are polygenic (multi – allelic). The epistatic effects of I and C genes with the E genes give rise to various plumage colours. Some of the effects (within and between loci) are of complete dominance, while others are of incomplete dominance. Recessive epistasis is common. E genes alone produce black plumage, while I and C separately produce white plumage. Several other genes only act to modify the effects of these major determinants of plumage colour (Smyth, 1990; Carefoot, 1990). Eumelanin inhibitors which are probably the primary pattern genes are Columbian (Co), Dark brown (Db) and Mahogany (Mh), while others like Dilutee (Di) and Light down (Li) have been described.

These interact with the E alleles, with each other and probably with unknown genes, to give rise to the various Columbian – like primary plumage patterns like Buff or Light Brahma – eb/eb, Co/Co db+/db+, mh+/mh+ (Moore and Smyth, 1971), New Hampshire (has intermediate amount of black, hence has a red tail) – ewh/ewh, Co/Co, db+/db+, Mh/? (Smyth, 1970), Rhoda Island Red (with the most black) – ey y/ey, Co/?, db+/db+, Mh/Mh (Malone, 1975). Prat (Spanish breed characterized by orange – butt down and ginger – red adult plumage) – ewh/ewh, Co/Co, db+/db+, mh+/mh+ , Vasca (resembles New Hampshire) – ewh/ewh, Co/Co, db+/db+, Mh/? (Campo and Orozco, 1984), Villafranquina (characterized by a red tail and by large amount of secondary pattern on female black plumage) – eb/eb, Co+/Co+, Db/Db, mh+/? (Campo and alvarez, 1988).The dominant white mutation, I, is a breed characteristic of White Leghorns (Table 5) and most current commercial meat stocks that have been bred for the particular purpose (meat production). Dominant white is also an important contributor to several patterned breeds including the White Laced red Cornish, Buff Laced Polish and both the Old English and modern Red Pyle Games (Smyth, 1990). I is incompletely dominant to its recessive allele i+, which associated with the absence of the I – effect on pigment. The phenotypic effects of I depend on its epistatic effects on melanin, primarily eumelanin.

Table 4: Adult phenotypes associated with the multiple alleles at the E locus1

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Gene Symbol** |  | |
|  |  | Female | Male |
| Extended black | E | Solid black | Solid black |
| Birchen | ER | Non – black breaks on head and hackle; body black to finely stippled; marginal non – black lacing of upper breast of some birchen breeds due to modifying factors. | Dark wild – type with dark (black or finely stippled) wing bays (flight feathers) |
| Dominant wheaten | Ewh | Body varies from light salmon – brown to dark wheat colour; a little eumelanin may be present in hackle, wing and tail | Wild – type: same as e+ |
| Wild type | e+ | Body feathers are mixture of black and brown pigment in a stippled pattern, while breast is salmon – brown in colour and devoid of stippling | Wild – type: pyle – zoned black distribution (black breast and ventral plumage); predominantly non – black hackle, back, saddle, wing bar and wing bay |
| Brown | eb | Similar to e+, but has stippled non – salmon breast  Resembles e+, but feathers are less darkly stippled | Wild – type; same as e+ |
| Speckled | es | Resembles eb pattern | Wild – type; same as e+ |
| Buttercup | ebc | Resembles ewh, although more coarse black stippling present on back and breast | Wild – type; same as e+ |
| Recessive wheaten | ey |  | Wild – type; same as e+ |

Alleles are arranged in general order of dominance

**Source: Smyth (1990).**

The red – pyle patterns result from the removal by I of the eumelanin, but not the phenomelanin, from wild – type plumage. Thus, red – pyle females have salmon breast, while males have gold or red pigment in their hackles, wing bow and bay, back and saddle feathers.The C locus of the fowl is now known to be multiple allelic (Brumbaugh et al., 1973; Smyth *et al.,* 1986), but that the mutant phenotype referred to as recessive white (c) is the most prevalent among the white breeds and varieties that do not carry dominant white.

Table 5: Genes that result in white or essentially white plumage colour

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Symbol** | **Mode of inheritance** | **Phenotype of homozygote plumage** |
| Dominant white | I | Incompletely dominant | White |
| Dun | ID | Incompletely dominant | “Whitish” |
| Recessive white | C | Recessive to C+ | White |
| Red-eyed white | cre | Recessive to C+, c | White |
| Recessive albinio | ca | Recessive to C+, c, cre | White |
| Imperfect albinio | sal | Recessive to S, s+1 | Partially pigmented2 |

1Only sex – linked mutation of group, allelic to silver and gold

2Black plumage becomes grayish – tan and red plumage becomes light red

**Source: Smyth (1990).**

The recessive white (c) phenotype is a varietal characteristic of Plymouth Rock, Wyandotte, Minorca, Orpington, Jeysey Giant, Dorking, Langshan, Silky, etc. among the multiple alleles at the C locus, the following alleles, in their order of dominance are more common; C+ > c > cre > ca. the wild – type C+ allele appears to be completely dominant to all the others (Carefoot, 1981). Recessive white appears to be completely dominant to cre and ca, while the relationship between cre and ca is one of incomplete dominance (Smyth *et al.,* 1986). The down colours associated with homozygosity for three mutants, c, cre and ca, indicate that all but ca/ca can produce some melanin in the down. Recessive white (c) down varies most with some chicks being almost as dark as light coloured Barred Plymouth Rock males. In other cases, c/c chicks have amelanotic down. Downs of cre/cre chicks may either be white or slightly tinted with grey.

Adult plumages of all three c mutants are typically white, even though the chick down may have been melanized. The recessive whites (c) may show some pigmentation usually light grayish (Smyth, 1990). The ratios of expected occurrence of plumage variants presented by Smyth (1990) are as follows:

Black – E/E, E/ER, E/ewh, E/e+, E/eb, E/ea, E/ebc,

E/ey, i+/i+, MI/MI = 2

Brown – (ewh/ewh Co/Co db+/db+ Mh/?) = 1

White – I/I, I/i+, ID/ID, C+/C+, S/sal, s+/s+,

c/c, cre/cre, ca/ca, c/ca = 2

Black Brown – e+/e+, e+/eb, e+/es, e+/ebc, e+/ey,

eb/eb, eb/es, eb/ebc, eb/ey, es/es, es/ebc, es/ey,

ebc/ebc, ebcey, (eb/eb Co/Co), (Co/Co e+/e+)

(e+/e+ Ml/ml+), (eb/eb Ml/ml+) = 3

Buff (dull yellow – orange colour) - ewh/ewh, ewh/e+,

ewh/eb, ewh/es, ewh/ebc, ewh/ey, ey/ey,

(eb/eb Co/Co db+/db+ mh+/mh+) = 2

Light Red – (ewh/ewh Co/Co db+/db+ mh+/mh+), (ewh/ewh Co/Co

db+/db+ Mh/?), (ewh/ewh Co/Co), MI/MI, sal/sal = 3

Light Brown – (ey or ebc/? Co/Co db+/db+ Mh/Mh Di/Di)

= 4

Mottled – ER/ER, ER/ewh, ER/e+, ER/eb, ER/es

ER/ebc, ER/ey, (ewh/ewh Co/Co db+/db+ Mh/?), (ey/ey Co/?

db+/db+ Mh/Mh) (eb/eb co+/co+ Db/Db mh+/?), (Co/Co

ewh/ewh), Db/Db, Db/db+ (eb/eb Db/Db), (e+/e+ Db/Db),

(e+/e+ Db/db+), (eb/eb Db/db+), (ewh/ewh Db/db+) = 6

Arabic numbers represent the expected ratios of occurrence calculated based on Mendel’s principle of inheritance (Falconer, 1989).

The genetic determination of primary plumage pattern is an interplay of genotype and its modification by other genes with primary pattern effects (Smith, 1965). He also observed that physiological processes that are relatively unaffected by environmental components, controlled by a number of identifiable qualitative inherited genes, polygenic modifying complexes and the various interactions between these produce the final plumage colouration.

***2.3.6.1.2 The Secondary Patterns***

The distribution of eumelanin within individual feathers is determined by secondary feather patterns. Many of these patterns exist alternatively in silver or gold depending on whether phenomelanin is present or absent in the non – black feather tissue (Smyth, 1990). Most secondary plumage patterns of chickens are determined by autosomal inheritance. Although the major individual genes (E alleles, Co, Db, MI, mottling gene-mo, penciling gene – Pg, pied gene – pi, spangling gene – Sp, stippling gene – Sg+, lacing gene – Lg and barring gene – Bg) associated with specific patterns have been identified, it should be noted that unidentified modifying genes are still needed to produce high quality phenotypes (Carefoot, 1981).

Autosomal secondary patterns (Table 6) with respect to the stippling pattern showed that males are pyle – zoned black with phenomelanin present in the areas of sexually dimorphic feather structure. Females are finely stippled with dark and light brown, with the breast feathers salmon – coloured and lacking the stippling pattern. The wild – type chicks down shows prominent dorsal, lateral back and head stripes of dark brown pigment on a lighter tan ground colour. In the absence of major modifiers like Co or Db, a wild – type chick will develop into a stippled, salmon – breast female or a pyle – zoned wild – type male (Smyth, 1990). Penciling patterns are characterized by concentric rings wholly contained within the feather, while barring pattern has parallel stripes. Penciled and autosomal barred birds both display autosomal barring in their juvenile plumage. The modified autosomal barred pattern of the buttercup breed has been associated with the Db gene (Smyth, 1970; Moore and Smyth, 1971; Somes, 1980; Carefoot, 1981). In the single form, an outer ring of eumelanin conforms to the edge of the feather, the non black area being white or gold depending on the genotype of the single form at the S locus. The single lace appears in both sexes, but is modified in the sexually dimorphic regions of male plumage so that only the breast and ventral feathers of male are typically laced.

Double – laced feathers have an inside lace separated by a non – eumelanin space between it and the outer lace. The remnant of the third lace follows the rachis in certain feathers. The double – laced phenotype is present in the female only, males being typically wild – type (Smyth, 1990).

The genetic basis for lacing is complex. Kimball (1955) reported lacing to be due to an incompletely dominant gene (Lg). Moore and Smyth (1971) found that homozygosity for four genes, brown (eb), Columbian (Co), melanotic (MI) and lacing (Lg) were necessary for lacing.

The spangling pattern consists of a V – shaped eumelanic spangled located at the distal end of the feather. The remainder of the webbing, as was the case for lacing, may be white, or some shade of pheomelanin. This pattern appears in silver or gold. The golden breeds have the rectrices, sickles and tail coverts in solid black, while the silver has same in white with a lack – spangled tip. Females of both breeds have a larger spangle than males, an apparent consequence of estrogen – enhanced eumelanin activity rather than a sex – linked effect (Smyth, 1990).

Table 6: Genetic interactions that determine the autosomal secondary patterns in the domestic fowl

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Phenotype** | **Genotypes1** | | | | | |
|  | E alleles2 | Pg/pg+3 | Co/co+4 | Db/db+4 | Ml/ml+5 | Mo+/mo6 |
| Stippling | e+ | Pg+ | co+ | db+ | ml+ | Mo+ |
| Penciling | eb | Pg |  |  |  |  |
| Autosomal barring: |  |  |  |  |  |  |
| Hamburg type | eb | Pg |  | Db |  |  |
| Fayoumi type | ER | Pg | Co | Db |  |  |
| Buttercup | ebc | Pg |  | Db |  |  |
| Single lace | eb | Pg | Co |  | MI |  |
| Double lace | eb, ewh, ey | Pg |  |  | MI |  |
| Spangling | E or ER? | Pg |  | Db | MI |  |
| Mottling | E | ? | ? |  | ? | mo |
| Specking (Sussex) | eb or ewh? | ? | Co |  | ? | mo |

1Pure stocks assumed to be homozygous 2See descriptions in Table 4

3pg+ is wild – type stippling, while Pg allows non – stippled secondary patterns

4Co and Db are the Columbian and dark brown Columbian – like restrictors, respectively

5MI is the eumelanin enhancer melanotic

6mo is the mottling mutation

**Source: Smyth (1990).**

The down of spangled chicks is characterized by irregular or broken back striping. The head down of the silvers are essentially clear, while that of the gold show varying degrees of dorsal head streak. Spangling is not expressed in the early chick feathers. It is first apparent at approximately four weeks of age (Dunn and Landauer, 1930). Spangling phenomenon is generally attributed to the E allele, autosomal dominant gene (Sp), melanotic gene (MI), Dark brown gene (Db) and the Columbian gene (Co) (Smyth, 1990).

Mottling and pied secondary patterns are similar. Mottling causes white tip at the distal ends of certain proportion of the feathers and is a characteristic of the Ancona and Mottled Houdan breeds. Mottling appears on approximately one of every two or five feathers. Somes (1980) has shown that mottling, in part is responsible for the tri-color patterns, including speckled and apical spangling. The major genotypes depicting these patterns (Smyth, 1990) are as follows:

Stippling – (e+/e+ pg+/pg+ Co/Co Db+/Db+

ml+/ml+ Mo+/Mo+) = 9

Penciling – (eb/eb Pg/Pg) = 1

Autosomal barring – (eb/eb Pg/Pg Db/Db)

(ER/ER Pg/Pg Co/Co Db/Db),

(ebc/ebc Pg/Pg Db/Db) = 9

Lacing – (eb/eb Pg/Pg Co/Co MI/MI),

(eb/eb Pg/Pg MI/MI), (ewh/ewh Pg/Pg MI/MI),

(ey/ey Pg/Pg MI/MI) = 11

Spangling – (E/E Pg/Pg Db/Db MI/MI),

(ER/ER Pg/Pg Db/Db MI/MI) = 8

Mottling – (E/E mo/mo) = 1

Speckling – (eb/eb Co/Co mo/mo),

(ewh/ewh Co/Co mo/mo) = 5

Arabic numbers represent the expected ratios of occurrence based on Mendel’s principle of inheritance (Falconer, 1989).

**2.3.6.2 *Plumage colour variation***

Anyanwu *et al.* (1979) and, Mbap and Zakar (2000) reported that the sole feather colours of indigenous chickens were mostly black, brown, red or white. Mancha (2004) also noted sole colours of black, brown and white in the Jos Plateau area of Nigeria. According to the author, most observable differences in plumage colour have greatly reduced over the years, such that birds with white and brown feathers are the most dominant the world over. This had also been reported by Lesson and Walsh (2004).

Bogale (2008) in his work on indigenous chicken characterization observed complete red (48%), complete white (18%), white with red tips (8%) and multicolour (4%) plumages. Nthimo (2004) on the other hand reported that the Lesotho native chickens have sole plumage colours of black, white, brown, red and grey. Nthimo (2004), Mogosse (2007) and Bogale (2008) observed that in the black plumage colour, the surface in both sexes is lustrous green-black or green-brown with considerable sheen on the slate or light-green under colour. Nthimo (2004) added that for Lesotho native chickens, the feather pattern is laced. Mogesse (2007) reported that male indigenous chickens of Ethiopia were multi- coloured. Most common combinations were varying shades of red with deep brown and black tails. Others had greenish sheen to the black feathers, multi-coloured wings and white striped tails. Some female chickens were also black or light brown with brown hackles. Female indigenous chickens have various types of plumage colours such as red (30%), white (18%), and white with golden breast (16%) black with white strips (8%) and reddish brownish (4%) (Badubi *et al.,* 2006). The authors noted that the white with golden breast was only observed only in the female chickens. Halima (2007) also reported similar variation in plumage colour of hens in Northern Ethiopia. Badubi *et al.* (2006) and Mogesse (2007) observed that mixed colouration were common with indigenous chickens in Bostwana, Zimbabwe and Ethiopia. These authors however, noted that mixed plumage colours vary with location within a region. Colour variation between male and female have been used in sex determination at day old and more recently as a model for gene action at cellular level (Brumbaugh *et al*., 1979).

**2.3.7 *Eye colour***

Eye colours in the indigenous chicken had been reported to be either red or pinkish (Mancha 2004). Nwosu and Okoye, 1978 reported orange iris and black pupil. Duncan (1955) reported that carotenoid pigment is found in several sites in the Iris, where it combined with the vascular system to produce the baby eye colour. The author added that photo receptor cone cells also contain oil droplets that have carotenoid pigment dissolved in the eyelid. These droplet colours appear to be specific for cone type; singles have red, white and yellow while doubles and accessories are yellowish-green. Meyer (1987) reported that the exact role of these oil droplets in vision is yet to be established. The author observed that both the baby, pink and red eye colours of albinos and semi-albinos are due to circulating erythrocytes and concluded that a similar situation is found in the redish-pink eye colour of the indigenous chickens.

**2.3.8 *Beak colour***

The chicken unlike mammals has no teeth. The mouth is in the form of a beak, which is thick and pointed (Obioha, 1992). The author stated further that the beak is used for obtaining food, building nest, turning eggs, caring for chick and preening feathers. The beak is commonly black, though light brown colours also exist (Nwosu and Okoye, 1978). Mancha (2004) reported that three types of beak colours were observed in Southern Plateau Local Government Areas of Nigeria. The brown beak chickens accounted for 43.09%, black (30.7%) and yellow (26.21%). Salibian and Montalti (2009) reported that on the dorsal surface of the tail of most birds is a small oil gland (uropygial gland or oil gland) which supplies oil for keeping the feathers glossy and waterproof and prevent the beak from becoming brittle. Lucas and Stettenheim (1972) reported that the yellow colour of the beak is due to the presence of xanthophylls, otherwise it is usually black.

**2.3.9 *Earlobe colour***

Oluyemi and Roberts (1979) reported that red earlobe predominates in samples of indigenous chicken. Mancha (2004) reported that brown earlobe was more frequent than white. The ear lobe varies in size and is sometime pinkish (Nwosu and Okoye, 1978). Ssewannyana *et al*. (2001) observed that earlobe is mostly white or red, while Bogale (2008) reported red (54%) and white (46%) as common earlobes.

**2.3.10 *Shank and skin colour***

Oluyemi and Roberts (1979) reported that the shanks are covered with scales which vary in colour usually black, green, blue or yellow. Ikeobi *et al*. (2001) reported three shank colours, black, white and yellow. The authors noted that black predisposes to high heat load, metabolic rate, thyroid activity and reduces survival. Mbap and Zakar (2000) and Saidu (2002) reported four shank colours white, black, red and yellow. Ssewannyana *et al.* (2001) also noted four shank colours but frequently yellow, black, white and grey. Bogale (2008) reported yellow shank (34%), white (18%) and bluish - black (18%). Oluyemi and Roberts (1979) stated that yellow shanks are due to presence of lypochrome pigments when melanin is absent and intensity depends on the amount of xanthophyll in the ration. They noted further that black shank is due to the presence of melanin pigment in the dermis, and when it occurs in the epidermis, the colour is greenish. When both melanin and lipochrome pigment are absent, the shank is white. Lucas and Stettenheim (1972) also reported that yellow shank colour is due to the presence of xanthoplyll. Oluyemi and Roberts (1979), Crawford (1984) observed that the skin of chicken is usually pigmented and of various colours. This is due to the presence or absence of melanin in the skin. Mancha (2004) also reported two skin colours; white and yellow and attributed the observed pale skin colour on vents of laying hens to the diversion of the yellow pigment to egg yolk formation. Ssewannyana *et al*. (2001) and Saidu (2002) reported that most chickens have white skin with a few yellow types. Lucas and stettenheim (1972) reported that yellow coloured skin is due to xanlthophyll. Horst (1988) and Smith (2001) also opined that the caroteniod of the chicken skin is the yellow fat-soluble xanthophyll. These authors added that xanthophyll is not synthesized by fowl and must be provided by ingestion of feedstuffs such as yellow corn, alfalfa leaf meal etc. Smith (1990) in addition reported that yellow pigmentation of the body which is more in cocks than hens could probably be due to diversion of the pigment to egg yolk formation. Eriksson *et al.* (2008) further reported that skin colouration in birds is due to presence or absence of carotenoids. They observed that carotenoid are taken up from the circulation by both white and yellow birds but are degraded by beta-carotene deoxygenase 2 ( BCDO2) from the skin of those carrying the white alleles (W\*W)’.The authors also noted further that yellow skin is caused by the recessive allele (W\*Y) that allow deposition of caretenoids. In addition, cis action and tissue specific regulatory mutation (s) inhibit the expression of BCDO2 in yellow birds.

***2.3.11 Body weight***

Body weights of indigenous chickens show considerable variation (Nwosu and Omeje, 1984). At maturity, live weight varies with strains, production status, management practices and season (Ozoje and Ngere, 2002). Mancha (2004) stated that under similar management and seasonal conditions, weight differences could partly be accounted for by genetic variation. The author also added that live weight difference could occur between locations and populations. He further stated that due to crossbreeding and family level selection preference (consciously and unconsciously); a flock or could vary in weight, especially when such populations are isolated. With good nutrition and management, the heavy Fulani chicken ecotype can attain mature body weights of 1.5 – 2.5kg (Atteh, 1990). He however reported that the mature body weight of indigenous chickens (usually more than 24 weeks of age) is 0.98-1.42kg for hens, average 1.29kg and 1.46 – 2.21kg (1.76kg) for cocks. Nwosu and Asuquo (1985) futher reported body weights of 92.0 ± 2.1, 289.0 ± 2.2, 581.0 ± 4.4, 744.0 ± 0.01 and 980 ± 4.1g in indigenous chickens of South Eastern Nigeria at 4, 8, 12, 16 and 20 weeks respectively and an average daily gain range of 5.7 to 9.4g.

Mbap and Zakar, (2000) reported a mean and range of 3.03 kg 2.59 – 3.68kg for matured Fulani ecotype in Yobe State, Nigeria. Essien and Joy (2003) also reported a range of 0.87 – 1.9kg in Cross River State, Nigeria. Okoh *et al.* (2009) observed body weights as 1.860.04 for males and 1.57.0.01 for females in Benue, Nigeria. Mancha (2004) reported a value of 1.38.0.5kg (0.96 – 1.71kg) on the Jos Plateau. Mature body weights had also been found to range from 0.6 to 3.9kg (Mancha, 2004) and 0.8 to 2.3kg (Nwosu, 1979 and Ibe, 1990). Studies by Adedokun and Sonaiya (2001) showed that female body weights were: 23 ± 1.6; 104 ± 14.5; 262 ± 4.8; 605 ± 67.5; 765 ± 103.4 and 948 ± 130.6g at 0,4,8,12,16 and 20 weeks respectively. Adedokun and Sonaiya (2001) reported hatch weight of 231.6 and 29g for female and male chicks respectively in the derived Savannah zone of Nigeria. The authors also found a significant difference in hatched weight of male chicks between the Derived Savannah (291.0g) and Rain forest (24). Nwosu *et al.* (1985) stated that the indigenous chickens weighed 1.14 and 1.27kg at point and end of lay. Matured body weights of indigenous chickens had been reported to vary with location and ecotype (Jeffry and Berg, 1972). Bogali (2008) reported that indigenous male and female may reach 1.3kg 1.0kg respectively in 6 month. Smith (1990) however reported that indigenous males attained 1.5kg in 6months and females about 30% less. Teketel (1986) observed that under station condition, indigenous birds reached 61 and 85% of white Leghorn body weight at 6months and at maturity

In Ethiopia, Halima (2007) reported weight of day old chicks to be 27.3g for the Melo-Hamusit while those of Fogera varied from 22.22 to 43g depending on size of hatched eggs (Bogale, 2008).The author also observed that weight at 6 months for pullets and cockerels were 933.333.3 and 1125 with ranges of 900 – 1000 and 1100 – 1150g respectively. Msoffe *et al.* (2007*)* reported that the average hatched weight for local chicken studied in Tanzania was 25.703g with a range of 14-34g. In Tanzania, Lawrence (1998) reported mature weight values of 2708 and 1827g for male and female Kuchi, other corresponding values were Singamagazi, 2915 and 2020g; Mbaya, 1621 and 1394g; Morogovo, 1850 and 1107 and Ching’ Weke 2100 and 1441.7g. Tadelle *et al.* (2000) and Sonaiya (2001) have also found that improving the environment of the indigenous flocks brings about increase in body weight and other production parameters. Badubi *et al.* (2006) reported that body weight of chickens in Botswana varied across regions and sexes. Bogale (2008) reported an average weight of 1180g of indigenous hens at Wareda, Amhare State, this is higher than 1035g reported for central Highlands of Ethiopia.(Halima, 2007). Some (1990b) reported average of 0.6-1.6kg. Reports from Malawi (Safalaoh, 2001) and Uganda (Ssewanyana *et al.,* 2001) however gave a range of 0.82 – 2.3kg.

***2.3.12 Linear body measurements***

Linear body measurements on indigenous chickens in Nigeria started more than 5-6 decades ago (Hill, 1954; Hill and Modebe, 1961; Nwosu, 1979).

**2.3.12.1 *Body length and height***

Mbap and Zakar (2000) reported average and body weight range of 23.98cm and 22.66-25.85cm respectively for matured indigenous chickens in Yobe. Okon *et al***. (**1997*)* hadearlierreported a value of 25.00±0.21cm in Calabar. Mancha (2004) also reported 17.95±0.18cm for chickens on the Jos Plateau while Okoh *et al.* (2009) observed body length value of 19.84 ± 0.14cm in Benue state. Mancha (2004) reported 28.140.57cm mean body height for chickens in Jos Plateau. Badubi *et al.* (2006) similarly observed that that the average body lengths of the male and female in Botswana chickens were 18.12.3cm and 20.22.9cm respectively.

Body height according to Jeffrey and Berg, (1972) reflects skeletal size and is a good indicator of live weight. Duguma (2006) reported a mean body height of 22.59cm for Horro chicken ecotype with corresponding values of 27.1 and 21.7cm for male and female. The author further reported a mean of 22.71 for Tepi ecotype with 26.4 and 21.7cm for males and females and 21.77cm for Jarso with corresponding of 25.3 and 20.9 cm for the sexes. The Brahma breed has a height of 91cm and stands at 2.5 feet tall (APA, 2012).

**2.3.12.2 *Body and girth circumference***

Mancha (2004) reported mean body circumference of 41.38 for chicken in Jos Plateau. The author also observed that body circumferences did not vary significantly with location of study. He also reported mean body girth of 31.77 for indigenous chickens in the Southern zone of Plateau state. The author also noted that body girth varied significantly (P<0.01) with sex. However, the male chickens were also reported to have higher body circumference (Okpeku *et al.,* 2003 Fayeye *et al.,* 2005). Obioha, (1992) reasoned that this is expected since male chickens are normally bigger and exhibit overall masculine frame. Okon *et al*. (1997) reported mean body girth of 37.38 for chickens in Calabar. Girth circumference had also been reported to vary significantly (P<0.05) with plumage colour and earlobe colour. Breast girth of 6.02 ± 0.13cm had been reported (Nwosu and Okoye, 1978)

**2.3.12.3 *Tail length and width***

Badubi *et al.* (2006) reported that the tail length of indigenous chicken varied in three Agricultural regions of Botswana. The authors gave tail lengths of 17.9 and 22.1 for Central, Maun and western region respectively. The authors further reported that tail lengths between males and females were significantly (P<0.05) different.

***2.3.12.4 Shanks and spurs***

***(a) Spur variants***

Metatarsal leg spur development is a characteristic of the male chicken only (Washburn and Smyth, 1967). At one day of age, spur caps composed of hard keratin can be observed in both sexes. As the chick grows, the male spurs begin to develop, while those of females remain dormant (Punnet, 1932; Somes, 1990b). It seems the trait is controlled by an autosomal recessive gene (and not influenced by season and diet) since no F1 or F2 male progeny of affected males manifest the trait (Some, 1990b, Kirby, 1994). At about six months of age, the bony spur fuses with the tarsometatarsus and becomes permanently attached to the skeleton (Crawford, 1971). Spurs continue to grow throughout the bird’s life (Somes, 1990b). Double spurs is caused by the (ds) gene. This gene has irregular dominance and poor penetrance in homozygotes (Somes, 1990b; Wrigh, 2009). Double spurs may develop on both legs. The two spurs on the affected leg (s) sometimes differ in size with no fixed relationship to each other.Spurlessnessis caused by an autosomal recessive gene (sl) (Punnet, 1932; Crawford, 1971; Somes, 1990b). Auxiliary spurs are extra bilateral ones just above the normal. They are distinguishable from week 18 and continue to grow but hardly exceed two centimetres. Washburn and Smyth (1967) reported that the trait is inherited as an autosomal dominant (As) with complete penetrance. Multiple spurs are a unique characteristic of breeds like the Sumatra whose males develop three to five of them on each shank with the second spur from the top being the longest (Somes, 1990b). He continued that each spur has its own bony cores, but only the longest ones are directly attached to the tarsometatasus. In newly hatched chicks, as well as in adult females, the normal single spur papilla is replaced by 3-5 enlarged and flattened scales which make it possible to classify this condition accurately at hatching. Multiple spurs is due to the gene (M) and is inherited as an autosomal incomplete dominant trait with heterozyogotes usually exhibiting two spurs and homozygotes three to five (Punnet, 1932; Hutt 1949; Somes, 1990b). Moulting spur is a unique feature of some males. The spurs are shed each year. Such spurs never develop beyond short nubbins with rounded tips. The bony cores are not united with the tarsometatarsus.

**(b) *Shank and spur lengths***

Mancha (2004) reported that males had significantly (P<0.001) longer spurs (1.44±0.09cm) than females which was more / less than the overall spur length (0.88±0.09cm) by 0.56cm. He further stated that birds with leg spurs had longer (9.85±0.14cm) shanks than those with spur caps (7.13±0.15). Shank length of 7.01 ± 0.1cm has been reported (Nwosu and Okoye, 1978). Fairfull and Gowe, (1986) in their study on two groups of hen reported a non significant difference in length of spurs on right and left legs and that heterosis was not significant for spur incidence or length. They further reported that spur length was negatively correlated phenotypically with egg production, egg weight, specific gravity and haugh unit but genotypically, was positively correlated with part-record egg production and negatively correlated with egg weight and specific gravity. Shank lengths of Melo-Hamusit and Gassay cocks in Ethiopia at 22 weeks under intensive management were 11.3 and 10.83 respectively (Halima, 2007). The author also reported shortest shanks in Mecha (7.50cm) that was not significantly different by sex.

***2.3.13 Productivity***

***2.3.13.1******Egg production***

Egg production is an interplay of genetic, various biochemical processes; anatomy and physiology (Fairfull and Gowe, 1990). It is also influenced by nutrition, age and weight of bird, stage of production, management and the environment (temperature, relative humidity, light and ventilation) (Oluyemi and Roberts, 1979; Williamson and Payne, 1978). Egg production is mostly measured as number of egg per clutch or hen housed or hen-day production. Mancha (2004) defined it as the number of eggs from the clutches per bird per year. For hen-housed egg production zero is a valid observation for an individual hen (Fairfull and Gowe, 1990).

1. ***Age at first egg***

Omeje and Nwosu (1983) reported that the indigenous chicken of Nigeria comes into lay as early as 157 ± 3.21days. However, higher age at sexual maturity of 150-169 days (169.5 ± 2.8days) had been reported (Akinokun, 1990). Work from three agro-ecological zones of derived and guinea savannah and, rainforest of Nigeria by Adedokun and Sonaiya (2001) reported values of 157 ± 3.7, 160 ± 3.8 and 165 ± 3.7 respectively. Akinokun (1990) reported a higher age at first egg in Savannah and Rain Forest agro-ecological zones than Momoh (2005) respectively. Momoh (2005) reported that age at first egg production is variable because it is affected by feeding and management practices. Age influences egg production within the first and subsequent laying cycles.

Mogesse (2007) reported age at first egg of indigenous chicken ecotype of Ethiopia as 144 days. Ali *et al.* (2003) also reported 144.3 days as the age at first egg production of indigenous chicken ecotypes of Tanzania. Mebratu (1997) observed a higher age at first egg than reported by Mogesse (2007). The author observed that age at first egg ranged from 166 to 230 days for indigenous chickens. Rahman *et al*. (1997) reported that Fayoumi female chickens took 231 days to reach maturity.

***(b) Potential for egg production***

The potential for egg production in indigenous chickens is about 30 to 40 eggs per annum (Tadelle and Ogle, 2001). Studies at Wolita Agricultural Development Unit, Ethiopia (Kidane, 1980; M.O.A., 1980) indicated that average annual egg production of indigenous chickens under the village conditions was 30- 60 eggs while 34 eggs/hen/year was observed at Asela Livestock Farm (Brannang and Pearson, 1990). Indigenous chickens lay 60 – 80,100 and 124 eggs per hen per year under extensive, semi intensive and intensive (battery cage) systems respectively (Hill and Modebe, 1961). An annual production of 128 eggs per indigenous hen on deep litter (Nwosu *et al.,* 1985) and 146 survivors’ egg number on 2-tier battery cage (Nwosu and Omeje, 1985) have also been reported. Some local birds like the White Chittagong of India however produce 130 eggs per year, while the Canton of Malaysia produces 120 eggs per annum (Williamson and Payne, 1978). Mebratu (1997) identified five local chicken ecotypes in Ethiopia with the following egg production averages per year; Tikur, 64, Melata, 82, Kei 54, Gebsima 58 and Malawi local chickens 64.

Short-term egg performance (first 120 days) was 48.5 ± 4.1 while annual average hen-day rate was 41.42% (Nwosu, 1990). Adedokun and Sonaiya (2001) reported 80 – 90 egg per hen per 280 days for indigenous chickens from derived and guinea savannah and, rain forest zones; however those kept under intensive management had hen- day peak of 54.9, 53.5 and 44.7% respectively. An earlier study on indigenous chickens by Sonaiya *et al.* (1998) under similar condition reported total annual production of 80 – 112eggs. Sonaiya (1990) reported values of 94, 80, 101, 97, 84 and 104 eggs per year for local chickens in Kaduna, Ilorin, Makurdi, Jos town, Sagamu and Nsukka, respectively. Branckaert(1997) reported that in the far East , an indigenous hen produced an average of 40 eggs in two cycles a year, The egg production of local chickens can be raised to 99 per hen per year with improved feeding, housing and health care (Tadelle and Ogle 2000). Under intensive management, the exotic fowl produces a maximum of 300 eggs in the first year, however 250 per year is considered satisfactory (Oluyemi and Roberts, 1979). In the tropics, exotic egg lay is 180 to 200 per year.

***(c) Clutch number and size***

Chickens lay eggs on successive days collectively called the clutch with intermediate pauses of one or more days (North, 1976). The total number of eggs in a clutch is the clutch size (Omeje and Nwosu, 1984). Numbers of clutch sizes per year are used to measure egg production under scavenging condition (Fairful and Gowe, 1990). Under intensive management system, Omeje and Nwosu (1984) reported 16 ± 1.0 clutches with an average size of 3.1 ± 0.2 egg for the Nigerian indigenous chicken in a short term egg production period (Point of lay – 120 days of lay). Under extensive system, they lay up to three clutches of 12 – 18 eggs per year (Williamson and Payne, 1978). Otchere *et al.* (1990) reported average clutches / year and clutch size of 2.9 and 10.4 respectively for Nigerian indigenous chicken under scavenging system. In Benue and Nasarawa state of Nigeria, Uza *et al. (*2001) reported an average of 3 clutches per year for local chicken, with about 21 eggs per clutch. Spadbrow (1997) reported 3 clutches of eggs each year. Number of clutches showed negative phenotypic correlation with clutch size (Omeje and Nwosu, 1984).

***(d) Body and egg weights at first production***

Omeje and Nwosu (1984) found that body and egg weights at first production (BWFE) of indigenous chickens of Nigeria were 851.67 and 25.97g, respectively. Gwaza (2010) however reported a mean weight at first egg of 1.181±0.033kg. Momoh (2005) reported BWFE of 840.43±9.35g for heavy ecotypes, 707.08±4.89g light weight; 818.83±4.86g for main, while reciprocal crosses had a value of 806.16±4.54 at 16 weeks of age. He further reported 20 weeks body weights of 976.08±11.21, 830.55±5.52, 936.89±7.32 and 933.58±4.54 for heavy, light ecotypes, main and reciprocal crosses respectively. The corresponding first egg weights were 38.06±0.32, 30.42±032, 35.08±0.33 and 35.83±0.34g. Body and egg weight at first egg have positive relationships to egg production (Momoh, 2005).

*(e)* ***Pause number and length***

The pause is the interval between clutches and there are several in a given period (Momoh, 2005). The author further stated that determination of pause number and length are possible only under battery cages where birds are housed singly and individual egg production recorded daily. Omeje and Nwosu (1984) reported pause number and length of 15 ± 1.1 and 3.0 ± 0.4 days respectively in indigenous chicken during a short-term egg production period. They added that the poor egg performance of indigenous chicken under extensive system is probably tied to poor management, long pauses of 3 days, low clutch number and sizes of 16 and 3.1 respectively.

***(f)******Broodiness***

Broodiness is the action or behavioural tendency to sit on a clutch of eggs to incubate them (Merriam, 2012). It is a maternal ability that allows the indigenous chicken to lay a few eggs in a clutch, sit on, incubate and raise the brood to a certain age, which is under endocrine control (Obioha, 1992). Omeje and Nwosu (1983) reported 4.4% broodiness in indigenous chickens monitored under short-term egg production. Broodiness is an advantageous mothering ability under extensive management, and to reduce broodiness, eggs are removed (Obioha, 1992).

***(g) Egg mass***

Egg mass output is by far the best measure for matching nutrient intake to egg output, it is the product of egg number and weight (Heddwyn, 2005). Nwosu (1990) reported an annual egg mass of 5.64kg for Nigerian indigenous chicken. An earlier study by Nwosu and Omeje (1985) however reported value of 168.5g on cage and 183.26g on deep litter. For two ecotypes chickens Momoh (2005) reported egg mass of 5740.85g for heavy ecotype and 5008.21g for light ecotypes in Nigeria. A large egg have relatively lower shell surface which is an obstacle to normal gas exchange.

***2.3.14 Egg quality***

Physical egg quality parameters are broadly divided into external and internal (USDA Egg Grading Manual, 1968). The external quality refers mainly to outer observations on the intact egg by means of non-destructive examination but including shell quality (Narushin and Romanov, 2007) The authors stated that the internal quality refers to observations on the interior components and that the characteristics of the egg play important roles on integrity, processes of embryo development and successful hatching. The most important parameters to successful hatching are weight, shell attributes, particularly thickness, porosity and shape index, and consistency of content (Tsarenko and Kurova, 1989). Consistency of contents is estimated from indices of albumen and yolk and haugh unit (Tsarenko, 1988).

***2.3.14.1 External qualities***

1. ***Egg weight***

Hill and Modebe (1961), Adedokun and Sonaiya (2001) and Peters *et al.* (2002) indicated that Nigerian indigenous chickens showed great variation in egg weight. Nwosu and Omeje (1985) reported egg weights of 33.37 and 35.61g for indigenous chickens of Nigeria on battery cage and deep litter management systems respectively. Nwosu (1990) reported 38.6g, Hill and Modebe (1961) 29 – 56g with an average of 40g under intensive management. Sonaiya *et al.* (1998) however observed 36 – 41g, Adedokun and Sonaiya (2001) reported 39 ± 1.0; 37.9 ± 1.0 and 37.1 ± 1.0g for derived, guinea savannahs and rainforest zones respectively, with overall mean of 38.0 ± 1.0g. A study by Peters *et al.* (2002) reported a value of 39.99 ± 0.8g with a range of 38.38 – 42.62g. The egg weights of local chickens from different regions of Nigeria have been reported to range from 31 to 49g (Ayorinde, 1987). These values are lower than 58.90g from 25-33 week old domestic fowl from New Busa (Ayorinde, 1987), 44.95-59.09g from 25-78 week old commercial layers (Awosanya *et al.,* 1998), 57.42g from exotic Shika Brown (Malami and Kwaido, 2002) and 61.42g from 35-week old harco layers (Adeniji and Balogun, 2002). Other researchers (Barnnang and Pearson, 1990; Singh, 2000) have reported and average of 50g egg weight from exotic breeds.

Msoffe *et al.* (2007) reported mean egg weight of 42.50.6g for seven indigenous chicken ecotypes of Tanzania. Mwalusanya (1998) however reported a mean egg weight of 43.6g for three ecological zones of Tanzania. Barua and Yoshimura (1997) reported 27g for indigenous chicken in Bangladesh. Weight of 38.2g has also been reported (Katule, 1992). Zaza (1992) also reported a mean egg weight of 48g in Dandrawi domestic fowl of Egypt. Msoffe *et al.* (2001) and Katule, (1990) had shown that egg weights from indigenous chicken of various genetic group vary significantly. Egg weight measurement is important because of its direct relationship with the size of the day-old chick (Moran, 1990) which is 64 -70% of the weight of the former (Merritt and Gowe, 1965).

***(b) Egg length and Width***

Egg length is the longest portion observed on the external surface or its long borders (Gunlu *et al.,* 2003). He defined egg width as the shorter portion of the egg which refers to the breath or the short border. Egg length and width are a measure of surface area and can also be used to predict shell quality characteristics, hatchability and chick weight (Mebratu, 1997), interior parameters (Narushin, 2005). The positive relationship between egg weight, length and width had similarly been reported by Choprakarn *et al*. (1998). In Nigeria, Mancha (2004) reported an egg length of 4.96±0.02 cm, a higher value of 5.77-6.12cm had been reported earlier (Mbap and Zakar, 2000) and 6.24cm among Olympia black layers in Akure, Nigeria (Chineke, 2001). Amankwah (2013) reported an egg width range of 3.81- 5.78cm with mean of 4.35cm.

Abanikannda *et al.* (2007) reported a mean egg length of 56.27±0.05mm for laying birds from 22 to 76 weeks. The authors further reported lengths of 56.17, 53.69, 56.00, 54.30, 57.06 and 57.23mm for ages 22-32, 33- 43, 44-54, 55-65 and 66 -76 weeks respectively. They further reported mean egg width of 42.45± 0.03 and values of 42.39, 40.79, 42.42,42.62, 43.01 and 42.80mm for ages 22 -32, 33 - 43, 44 -54, 55 - 65 and 66 - 76 weeks respectively, indicating a consistent increase with increasing age of hen.

**(c)** *S****hape index***

Egg shape, described in terms of ratio of maximum breadth and length, remains constant as long as the egg is intact, eggs that are more oblong in shape have low index values (Mebratu, 1997). Mbap and Zakar (2000) reported an average index of 0.633. Ayorinde (1987) obtained higher values for Shaver birds (0.78) and Olympia black layers (0.763). Indigenous chicken in Ethiopia have been reported to have egg shape index of 0.711 ± 0.057 as opposed to 0.76± 0.0026 for exotic breeds (Mebratu, 1997). Kumar and Shingari (1969), Tsarenko (1988) and Burtov *et al.* (1990) reported that eggs of normal shape (oval and tapering towards the smaller end) hatch more successfully than abnormally shaped ones. The embryo changes its axial orientation during the later stages of development (Ragozina, 1961; Rolnik, 1970). Therefore, both narrow and markedly oval eggs are more likely to impede embryo rotation and hatching (Rolnik, 1970; Provizen and Lvova, 1982; Harun *et al.,* 2001). Egg shape also attracts consumers’ attention, with preference being given to normal shapes (Narushin and Romanov, 2007). It has been reported that egg index decreases with increase in body weight (Mebratu, 1997).

***(d ) Egg shell colour***

Most eggs are predominantly white or brown (Buss, 1982), but green or blue shells have been reported among Araucana in South American. White shell (36.67%), brown (33.33%) and cream (30.00%) have been reported for local chickens in Yobe State, Nigeria (Mbap and Zakar, 2000). It has been observed that shell colour affected interior quality; with brown showing better quality than white (Curtis *et al.,* 1985). Buss (1982) on the contrary observed no difference in interior quality between brown and white eggs. He however observed that white shells were thicker and heavier, hence stronger. Shell colour is a visual appraisal. It is not usually considered in the U.S. standards of quality or grade of egg classification but, it is among the first characteristics that attract consumer’s attention (North, 1978). He also stated that egg colour preference varies with society.

***(e) Shell integrity and thickness***

The soundness of egg shell is its fitness or strength or ability to allow the egg to go through handling processes without damage. It is a function of shell strength. Eggs with weak and thin shells are likely to break at one stage or the other (Stadelman, 1977).

Egg integrity can be classified as sound, checked, cracked, leaking, smashed and shell-less (USDA Egg Grading Manual, 1968). The last five are considered unsound but their contents are not necessary bad. A sound egg is one whose shell is not broken. A checked egg has a crack in the shell, but the shell membrane and content are intact. A cracked egg has a wider split without leaking. Smashed eggs are crushed or shattered. Shell-less eggs have no market value even though their contents are intact (Roland*,* 1980).

Several factors affect the integrity of the egg shell namely egg size, age of bird, stress, elevated environmental temperature, nutrition and water quality, genetics, management and disease (Roland, 1980). Irrespective of hen’s age, shell deposition remains fairly constant or only increases slightly, while egg weight and size increase at a faster rate, this results in a decline in shell strength (Roland, 1979; Roland, 1980). Proper dietary manipulations of protein, amino acids, energy and calcium in addition to phosphorus, magnesium, zinc, manganese, chloride, potassium and vitamins will greatly improve egg shell strength (Roland, 1979). Woolford (1985) reported that high ambient temperatures cause changes within the hen that have a major influence on shell quality; particularly reduction of carbondioxide and bicarbonate concentrations in the blood stream, results to poor shell development. A sound egg with shell thickness of not less than 0.33mm has 50% chances of being handled without destruction (Stadelman, 1977; Quereshi, 1985). Egg shell thickness of 0.36mm for domestic fowl (Ayorinde, 1987), 0.31mm for Olympia black layers at Akure, Nigeria (Chineke, 2001), 0.54mm for old black Nera birds (Iyayi, 2002) and 0.51mm for harco layers in Ilorin, Nigeria (Adeniji and Balogun, 2002) and 0.346mm for indigenous chicken in Ethiopia (Mebratu, 1997) have been documented.

Egg shell thickness and porosity affect embryonic development and hatching. Thick and strong shells protect the embryo from external insults. However, the shell should be sufficiently thin and fragile to allow hatching process (Narushin and Romanov, 2007). Coleman and McDaniel (1975) and McDaniel *et al*. (1981) reported a significant increase in early embryonic mortality among eggs with thin shells. However, extremely thick shells also result in increased embryonic mortality (Kurova, 1986; Narushin and Romaov, 2007).

Most researchers agree that a thick shell is to be desired for the following:

1. It encourages the best use of the nutrients contained in the egg by the embryo (Sergeyeva, 1976);
2. There is lesser chance of bacteria penetration (Fisinin *et al.,* 1990).
3. There is also lesser chance of dehydration ( Roque and Soares, 1994); and
4. It offers the best protection from mechanical damage (Sergeyeva, 1976; Tsarenko, 1988).
   * + 1. ***Internal qualities.***

The assessment of the internal characteristics of the egg can be carried out through the destructive technique which involves breaking it (Narushin and Romanov, 2007) or the nuclear-magnetic resonance, computer vision and acoustics. These methods are non-destructive assessment; the internal characteristics of the egg have to do with the consistency of contents (Kuchida *et al.,* 1999; Coucke *et al.,* 1999).

**2.3.14.2.1 Albumen *characteristics***

Albumen is the name for the clear liquid (also called the egg white or the glair / glaire) contained within an egg. In chickens it is formed from the layers of secretion of the anterior section of the hen’s oviduct (Scott and Silversides, 2000). The primary natural purpose of the albumen is to protect the yolk and provide additional nutrition for the growth of the embryo (when fertilized) (Stevens, 1996). The albumen has a major influence on the overall interior egg quality. Thinning of the albumen is a sign of deterioration which can be observed when a stale egg is broken on a smooth flat surface (Jacob *et al.,* 2000). Albumen quality is influenced by genetic and environmental factors such as temperature, humidity, presence of carbon dioxide, pH and storage time (Fayeye *et al.,* 2005). Others include nutrition and the hen’s age (Roberts and Ball, 2004). Loss of water from the egg through evaporation during storage is influenced by temperature and humidity and is detrimental to internal egg quality (Scott and Silversides, 2000).

1. ***Albumen weight***

Afolabi *et al. (*2012) gave range of 19.55 to 21.49g in chicken fed palm kernel cake added with palm oil in Nigerian chicken. Nonga *et al. (*2010) reported 21.9g as albumen weight. Scott and Silversides (2000) reported weights of 38.65, 39.29 and 40.63g in chicken of 32, 50 and 68 weeks of age. The authors further reported 40.57, 39.36 and 38.22g for eggs stored for 0, 5 and 10 days. In the Fayoumi, White Leghorn and Rhode Island chickens, Dottavio *et al. (*2005) reported 30.8±0.51, 35.7±0.56 and 40.1±0.72 as albumen weight. Markos *et al. (*2017) reported 22.2, 21.0 and 19.3 for highland, midland and lowland ecotype chickens in Ethiopia. Shi *et al.* (2009) reported 61.468, 62.506 and 64.643g in small, medium and large eggs. Amankwah (2013) reported albumen weight of 32.63g in Ghana chickens.

1. ***Albumen Height and width***

It is the height of the inner thick albumen when the egg is broken onto a flat surface which largely defines the quality of sound eggs for many years because it is measured and relates well to the freshness of the egg (Stevens, 1996). Defining egg quality by albumen height was likely reasonable when quality means freshness because time in storage is linked to a steady decline in albumen height (Williams, 1992). Scott and Silverside (2000) showed that albumen height is biased by age and strain of hen, and they suggested using the pH of albumen to measure freshness since it lacked the bias. The determinant of albumen height are not completely understood (Williams,1992) Reduced albumen height has been variously attributed to proteolysis of ovomucin, cleavage of disulfide bonds, interactions with lysozyme, and changes in the interaction between α and β ovomucins with no clear favourite(Stevens,1996). Peters *et al*. (2007) reported height of 3.35±0.08, 3.33±0.06 and 3.33±0.01 in naked neck, frizzle and normal feathered chickens in Nigeria. Bobbo *et al.* (2003) reported albumen height of 6.51, 9.19, 7.41, 6.80, 7.43, 7.51, 6.66, 7.11 and 7.03mm for frizzle by frizzle, frizzle by naked neck, frizzle by smooth feathered, naked neck, naked neck by frizzle, naked neck by smooth feathered, smooth feathered by smooth, smooth by naked neck and smooth by frizzle. Albumen height from ages 32, 50 and 68 weeks in birds were reported to be 6.47, 5.76 and 4.76mm and decreases with the age of the hen (Scott and Silversides, 2000). The authors further reported that storage at 0, 5 and 10 days were 8.45, 4.96 and 4.10mm for height respectively. Shi *et al. (*2009) reported heights of 10.274, 9.785 and 10.519mm in small, medium and large eggs. Markos *et al.(* 2017) reported 5.66, 5.66 and 5.05mm in highland, midland and lowland ecotype chickens in Ethiopia. Amankwah (2013) reported albumen height of 5.94mm in Ghana chickens. Nonga *et al.(*2010) reported 3.9mm as albumen height. Higher albumen height of 8.41±0.04 had also been reported for white leghorn (Pradeepta *et al.,* 2015). Bobbo *et al.* (2003) observed corresponding albumen width of 6.25, 5.31, 5.70, 6.01, 5.76, 5.84, 5.86, 5.26 and 5.19mm for frizzle by frizzle, frizzle by naked neck, frizzle by smooth feathered, naked neck, naked neck by frizzle, and naked neck by smooth feathered, smooth feathered by smooth, smooth by naked neck and smooth by frizzle.

1. ***Haugh unit***

The test was introduced by Raymond haugh in 1937 (Jeffey, 2010), and it’s an important industry measure of egg quality in addition to other measures such as shell thickness and strength (Monira *et al.,* 2003). For successful hatching interior of the egg has to be firm and must have high density for embryo development (Jeffey, 2010). Ayorinde (1987), Adeniji and Balogun(2002), Malami and Kwaido (2002), Mancha (2004) , Nonga *et al*. (2010) and Amankwah (2013) reported haugh unit values of 90.9, 57.93, 55.87, 56.60, 67.7 and 75.10 respectively. Pradeepta *et al.* (2015) had a higher value of 92.00±0.19 for white leghorn. Quereshi (1985) observed that a Haugh unit of above 60 is an indication of a firm and strong albumen.

1. ***Albumen ratio and volume***

Peters *et al.* (2007) reported ratios of 59.13±0.27, 58.37±0.29 and 55.63±0.12 in naked neck, frizzle and normal feathered chickens. Sezer (2007) and Islam and Dutta (2010) observed albumen ratio of 60.83% and 64% respectively. In the Fayoumi, White Leghorn and Rhode Island chickens, Dottavio *et al.* (2005) reported 59.8±0.38, 62.8±0.27 and 63.0±0.90%. Markos *et al.* (2017) reported 50.7, 50.7 and 52.5 for highland, midland and lowland ecotype chickens in Ethiopia. Amankwah (2013) reported albumen ratio of 54.80% in Ghana chickens. Scott and Silversides (2000) reported volume of 5.68, 5.70 and 5.89g in chicken in 32, 50 and 68 weeks of age. The authors further reported 5.15, 5.89 and 6.17g for eggs stored for 0, 5 and 10 days.

1. ***Albumen pH***

The pH values of albumen go through definite changes, presumably affected by natural metabolic process occurring within an egg (Romanoff and Romanoff, 1944). The authors further stated that the pH of egg albumen rapidly changed towards alkalinity and back during the first week of incubation, reaching the highest point of alkalinity at about 48 hours and gradually moved toward neutrality for the rest of the incubation period. Albumen pH increases with storage due to loss of carbon dioxide from the egg (Scoltyseek, 1981). He further stated that there is also decrease in viscosity and changes in taste and flavour in ageing eggs. Albumen pH of 8.71, 8.64 and 8.88 were reported in chickens of 32, 50 and 68 weeks of age, and 7.78, 9.12 and 9.26 in eggs stored for 0, 5 and 10 days( Scott and Silversides, 2000).

***2.3.14.2.2* *Yolk characteristics***

There are several measures of egg yolk quality (Kirunda and Mckee, 2000). They reported that yolk colour vary with chicken genotype, environment and pigments in food. As the yolk ages it absorbs water from the albumen and increases in size; this weakens the perivitelline membrane. This flattens the yolk and it becomes more or less fractured (Li-Chan and Nakai, 1989). They further reported that it is essential that the perivitelline membrane remains intact and strong in order to prevent the content of albumen and yolk from mixing, if this occurs, the quality of the egg and consumers acceptance decline. The yolk is also flattened and often displaced to one side as opposed to the fresh egg whose round yolk stays in a central position surrounded by the thick albumen (Jacob *et al.,* 2000).

1. ***Yolk weight***

Afolabi *et al.* (2012) gave range of 14.50 to 15.37g in chicken fed palm kernel cake added with palm oil. Amankwah (2013) reported 19.43g yolk weight. Scott and Silversides (2000) reported yolk weight of 15.16, 17.50 and 18.35g in chicken of 32, 50 and 68 weeks of age. The authors further reported 16.32, 16.86 and 16.91g for eggs stored for 0, 5 and 10 days. In the Fayoumi, White Leghorn and Rhode Island chickens Dottavio *et al. (*2005) reported 15.0±0.20, 15.0±0.25 and 16.9±0.23 as yolk weight. Markos *et al*. (2017) reported 16.5, 15.6 and 13.1 for highland, midland and lowland ecotype chickens in Ethiopia. Shi *et al.* (2009) reported 24.006, 23.329 and 21.391 in small, medium and large egg weight.

1. ***Yolk height and width***

Yolk height of 1.63 cm has been reported by Iyayi (2002). Values of 1.19cm have been documented by Malami and Kwaido (2002). Afolabi *et al.* (2012) gave a range of 0.96 to 0.99g in chicken fed palm kernel cake added with palm oil. Amankwah (2013) reported 16.35mm while Markos *et al.* (2017) reported 17.2, 14.9 and 13.5mm for highland, midland and lowland ecotype chickens in Ethiopia. Peters *et al*. (2007) reported egg width of 3.17±0.01, 3.32±0.01 and 3.22±0.01 in naked neck, frizzle and normal feathered chickens. Afolabi *et al.* (2012) gave a range of 5.37 to 5.63g in chicken fed palm kernel cake added with palm oil.

1. ***Yolk ratio***

Peters *et al*. (2007) reported 35.24±0.25, 36.59±0.26 and 30.05±0.22 in naked neck, frizzle and normal feathered chickens. Sezer (2007) reported yolk ratio of 30.49% while Islam and Dutta (2010) had 20%. Amankwah (2013) reported 32.84% as value for yolk ratio. In the Fayoumi, White Leghorn and Rhode Island chickens Dottavio *et al. (*2005) reported 29.1±0.44 26.4±0.29 and 26.7±0.35% as ratios. Markos *et al. (*2017) reported 35.7, 35.7 and 35.7 for highland, midland and lowland ecotype chickens in Ethiopia.

1. ***Yolk index***

Yolk index is the index of freshness of an egg; ratio between height and diameter of yolk under defined conditions. As the egg deteriorate the yolk index decreases (Encyclopedia.com 2017). Mancha (2004) observed a yolk index of 0.37±0.04 while Awosanya *et al.* (1998) had a range of 0.34 – 0.35mm Ayorinde (1987), Iyayi (2002) and Adeniji and Balogun (2002) reported yolk indices of 0.52, 0.45 and 0.43, respectively in Nigerian chickens. Values of 0.27cm have been documented by Malami and Kwaido (2002). Amankwah (2013) reported 38.81 as value for yolk index.

1. ***Yolk colour***

Yolk colour is used as quality determination factor but is nearly entirely dependent on the diet and is easily manipulated , darker yellow or orange yolks mean there is more carotenoids , which usually mean the hen had varied diet and are richer in micronutrients like vitamin A and omega -3 (Stevens, 1996). Studies have shown, however, that eggs from pasture- raised hens have more omega-3 and vitamins but less cholesterol due to healthier, more natural feed (Houton, 1982). Peters *et al. (*2007) reported yolk colours of 9.88±0.03, 9.03±0.04 and 8.96±0.03 in naked neck, frizzle and normal feathered chickens. Afolabi *et al. (*2012) also reported a range of 1.0 to 5.85 in indigenous chickens fed palm kernel cake with added palm oil in Nigeria.

***2.3.15 Fertility***

Fertility refers to the total number of incubated eggs that are fertile (Ajayi and Agaviezor, 2016). The authors reported fertility of 76.78±2.7, 91.37±0.5, 71.81±8.6, 69.23±8.6, 64.23±0.0, 81.74±9.8 and 73.82±0.0% in frizzle feathered chicken, frizzle cross normal feathered, normal feathered cross, normal feathered cross frizzle, normal feathered cross naked neck, naked neck cross, and naked neck cross normal feathered respectively. Adeleji *et al*. (2015) also reported fertility of 77.67, 67.72, and 85.59% in naked neck, frizzle and Fulani ecotype chickens. Fertility of 83% was reported among the Deshi breed of chickens (Bhuyian *et al.,* 2005), while Jayarajan (1992) reported higher egg fertility for White Leghorn and Rhode Island Red breed during the cold and summer seasons. Msoffe *et al.* (2007) reported 70% fertility in the indigenous chicken ecotypes of Tanzania, while Wilson (1979) reported 95% fertility.

The fertility of an egg depends on both the hen and the cock (Chambers, 1990). The author also opined that the fertility of an individual changes with time. Selection for growth generally results in decline in fertility (Brillard, 2004). Genetic and non genetic factors originating from male or female affect egg fertilization and embryo development. Fertility is therefore a function of the genotype of the embryo contributed by both parents (Decuypere *et al.,* 2003). Factors of egg fertility from the male include; sperm metabolism, semen concentration, sperm motility, and the presence of normal or dead sperm cell. Behavioural factors include efficient ability to mate (Wilson *et al.,* 1979). Female factors include behavioural and physiological attributes such as factors such as prevalence of sperm storage tubules, age, breed and period of lay (Ansah *et al.,* 1985). Msoffe *et al.* (2001) observed that fertility varied between ecotypes probably due to differences in the inherent ability to cope with environmental stress.

***2.3.16 Hatchability***

Hatchability refers to set egg that hatch (Ajayi and Agaviezor, 2016). The authors reported values of 62.09±8.9, 69.16±2.5,86.36±9.4, 55.56±0.0, 72.73±0.0, 66.90±3.2 and 63.33±0.0% in frizzle feathered chicken, frizzle cross normal feathered, normal feathered cross, normal feathered cross frizzle, normal feathered cross naked neck, naked neck cross and, naked neck cross normal feathered respectively( Ajayi and Agaviebor, 2006). Adeleji *et al. (*2015) reported values of 75, 81.4 and 84.16% in naked neck, frizzle and Fulani ecotype chickens. Okoh *et al*. (2010) on the other hand reported hatchabilities of 88.70±1.48, 82.55±1.23, 84.25±1.04 and 83.87±1.26% for frizzle, dwarf, naked neck and normal feathered chickens respectively. Hatchability in the indigenous chicken has been reported to be about 62% (Msoffe *et al.,* 2007). However, Wilson (1979) reported mean hatchability values of 90% in Sudanese domestic chicken. Barua and Yoshimura (1997) observed a value of 75% in indigenous Bangladesh fowls. Furthermore Bogale (2008) reported hatchabilities of five Ethiopian indigenous chickens to be 42, 41, 44.3, 39.3 and 39% percent. Hatchability is depended on egg weight (Morris *et al.,* 1968; Brah *et al.,* 1999; Gonzales *et al.,* 1999). Shatokhina (1975) found that the hatchability of eggs of 46-50g, and 66-74g were between 8 and 10.5% lower than those of 50-66g. A 10g increase or decrease in egg weight above the optimum value (50g) lowered hatchability by 10.7 and 3.9% respectively (Sergeyeva, 1976). Romanoff (1949) and Tsarenko (1988) also stated that hatchability depended on both egg weight and ratio of weight to shell surface area. Similarly, Deeming (1995) observed that hatchability did not only depend on weight, but also on egg shape and porosity.

**2.4 Relationship between Different Characteristics of Chicken**

**2.4.1 *Relationships among the body biometry of indigenous chicken ecotypes***

Mancha (2004) reported significant correlations among body biometry of indigenous chickens which ranged from 0.40 between wattle and neck lengths to 0.95 comb length and height. Okon *et al.* (1997) reported that shank width was the highest and only positively correlated (P<0.01) estimator of body width at 3 weeks. At 6 and 9 weeks body weight positively correlated (P<0.01) with body width, girth, length, keel and shank lengths and, shank width with values ranging from 0.34 to 0.74. Okon *et al*. (1990) also noted that at 12 weeks, body weight was positively correlated with body girth (r-0.59), keel length (r=0.55) and shank width (r=0.031). Shank length had been reported to vary with body length (Mbap and Zakar, 2000). Positive correlations of 0.29-0.81 between back bone, bird height, breast height and girth had been reported in chickens (Monsi, 1992)**.** Nwosu *et al*. (1985), Ikeobi and Oladokun; (1998) Adebambo *et al.* (1999) also reported that shank length is correlated strongly with body length, body height, live weight, keel length and body circumference. These authors concluded that these parameters could be improved through correlated response due to selection for shank length.

**2.4.2 *Relationship between body biometry and performance traits in indigenous chicken***

Several correlation coefficient values have been reported among body biometry and performance traits. Live weight had been found to be significant and strongly correlated with body length, body circumference, chest circumference and thigh length (Mancha, 2004). The high associations indicate that weight, length frame size and other are complementary. Okpeku *et al*. (2003) also stated that selection for any correlated traits may lead to improvement in the others. Mancha (2004) stated that information on correlation among body biometry and performance traits could be used effectively to exploit correlated response to selection even at the rural levels. He also reported significant correlations between live weight and shank length, comb length and height, body length and height, breast girth and body circumference. He continued that correlated live weight correlated significantly with comb length (0.748 P<0.001); comb height (0.638P<0.001), body circumference (0.746 P<0.001), breast girth (0.708P<0.001), shank length (0.638P<0.001), height (0.577P<0.001) body length (0.63P<0.05) and tail width (0.654P<0.05). Positive and significant correlations between live and egg weights, thigh length and egg weight had also been reported (Mbap and Zakar, 2000; Mancha, 2004). Selection of hens that are heavy and have longer thighs may therefore produce heavy eggs (Okpeku *et al.,* 2003).

**2.4.3 *Relationships between body biometry and qualitative traits of indigenous chicken ecotypes***

Mbap and Zakar (2000) reported that shank length among indigenous chickens in Yobe varied with feather plumage. The authors also observed that shank length varied with egg colour; and body weight varied with plumage, eye colour and shank colour. Egg width had also been reported by authors to vary with eye colour; number of eggs per clutch by shank colour had also been reported to be strongly associated with shank colour. They concluded that body length, body weight and shank length could conveniently be selected for using plumage and shank colour. They also stated that most egg characteristics can be improved by selecting for the appropriate qualitative traits. Ikeobi and Oladokun (1998) however, did not observe any relationship between eye and shank colour with shank length. Body length had been reported to be related to plumage colour (Mbap and Zakar, 2000). Pink and blackish-red plumage birds had the longest bodies (Mancha, 2007). This showed that body length could conveniently be selected for using plumage colour. Body circumference and shank length have also been reported to be related to plumage colour. Chest circumference varied with comb and earlobe colours. Similarly thigh length also varied with plumage and comb types (Mancha, 2004; 2007). Thus plumage, comb and earlobe colours and comb types could be selected for in order to improve chest circumference and thigh length. Skin and comb colours were also correlated to egg number. Yellow skinned hens laid more eggs than white skinned; the red combed hens laid wider eggs. Thus selection for larger clutch size and wider egg could be achieved using skin and comb colour variations respectively (Mancha, 2004).

**2.4.4 *Relationship between body weight, egg size and egg number***

Duplessis and Erasmus (1972) indicated that larger hens with higher body weight within a blood line laid larger eggs than those with smaller body weights. This was supported by Ricklefs (1983) who reported that bigger size and heavier weight hens produced bigger egg with longer laying length and heavier weight. The author concluded that, body size and weight and, egg size are positively correlated. Bohren *et al.* (1966) reported positive genetic correlation between body size and partial or full egg record. John *et al.* (2000) reported an average of 0.45 as genetic correlation between body size and partial or residual egg number from a commercial white leghorn population. Egg size can therefore be improved by selecting heavier birds.

**CHAPTER THREE**

**3.0 MATERIALS AND METHODS**

**3.1 Location of Study Area.**

The study was carried out in the North Central zone of Nigeria which has an average elevation of 1,300 m above sea level. The longitudes and latitudes of the areas are; Benue (7o,12'N ; 7o,29'N and 8o,45'E; 9o,24'E), Kogi (7o,12'N ; 7o,56'N and 7o,11'E; 6o,58'E), Nasarawa(8o,35'N ; 8o,37'N and 8o,09'E ; 9o,02'E), Niger (9o,27'N ; 9o,46'N and 6o,31'E; 7o,01'E) and the Federal Capital Territory (FCT) (9o,09'N ; 9o,20'N and 7o,14'E ; 6o,49'E) (Microsoft Encarta, 2008)

**3.2 Climate and Vegetation**

The North Central zone experiences a sub humid tropical climate with two distinct seasons, rainy and dry. The rainy season lasts from April to September and received from 1000- 2500mm of rain while the dry begins in October and ends in March. The two seasons are due to the moisture laden south westerly-wind from the Atlantic Ocean and the dry dusty north-easterly from the Sahara desert (BSN*,* 1982). Temperatures are high throughout the year averaging 30o C. Mean annual temperatures per state are Benue 30oC, Nasarawa 31oC, Kogi 29o C, Niger 30o C and the Federal Capital Territory 29oC. The relative humidity ranged from 47 to 85 % (TAC*,* 2002). The study area experienced mean daily sunshine duration of 8 hours (Amusan *et al.,* 2003). Soil type is basically sandy loam to sandy clay derived from decompose plant materials. The vegetation varies considerably. It is best described as savanna, a region of tall grasses and trees. The zone has been altered by human activities such as repeated burning and grazing into open grassland (Amusan *et al.,* 2003).

**3.3 Occupation**

Farming is the main occupation in the area. Crops cultivated includes: Yam, Soya beans, Rice, Cowpea, Cassava, Sweet potatoes, Sorghum, Maize, Millet, Cocoyam etc. Livestock and poultry are mainly kept as part time farming activities; Cattle, sheep, goats, chickens, ducks, geese, turkeys, pigeons and guinea fowls are kept.

**3.4 Birds Used and Data Collection**

Birds used for the study were scavenging indigenous chickens found within the study area and data were collected at Out - and - On stations

***3.4.1 Out- station***

***3.4.1.1 Birds management***

Traditional management was practised in the study area. Marked areas are provided for birds at night but are allowed to scavenge freely in the day. Supplementary feeds in the form of house hold refuse and grains were usually given in the morning before scavenging and later in the evening before rest. Water was supplied at various locations around the home. No vaccination was given and, diseases were controlled by slaughtering affected chickens.

**3.4.1.2 *Sampling and data collection***

The out station data were generated via participatory rapid appraisal technique.



Plate II:Common backyard poultry housing in Niger state

It is principally, an interactive rather than extractive approach where farmers were voluntarily allowed to provide information to researchers. The approach aimed at incorporating the knowledge and opinions of rural farmers. This technique is divided into four categories a. group dynamics e.g. feedback session b. sampling - transect walk and visit c. interviewing - semi structured interviews and d. visualization (Aichi, 1995).

Five local government areas (LGAs) were randomly selected from the four states and FCT and 100 sets of questionnaires (appendix 1) were distributed per LGA. Data were subsequently generated on socio – economic characteristics of farmers and management of chickens. Observable characteristics (including major genes characteristics) and body measurements were also carried on 6176 indigenous chickens as outlined by Adekoya *et al.* (2013) as follows:

Body weight -- Measured using a sensitive platform scale in kilogramme to two decimal places.

Linear measurements in centimetres were carried out using a flexible measuring tape.

Body length - Measured between the first cervical vertebrate and the pygostyle

Body width - The distance between the right and the left flank of the body (hind breast)

Beak length - The length of the upper beak rim

Shank length - The distance from the knee or knuckle (hock joint) to the region of the tarsus

Wing length - The distance from the caput humeral to the third carpal digit

Comb length - Taken from the posterior of the comb as the longest distance.

Breast length - Measured with a tape as the chicken was held on its back

Breast height - The distance from the base of the keel to the juncture of the neck

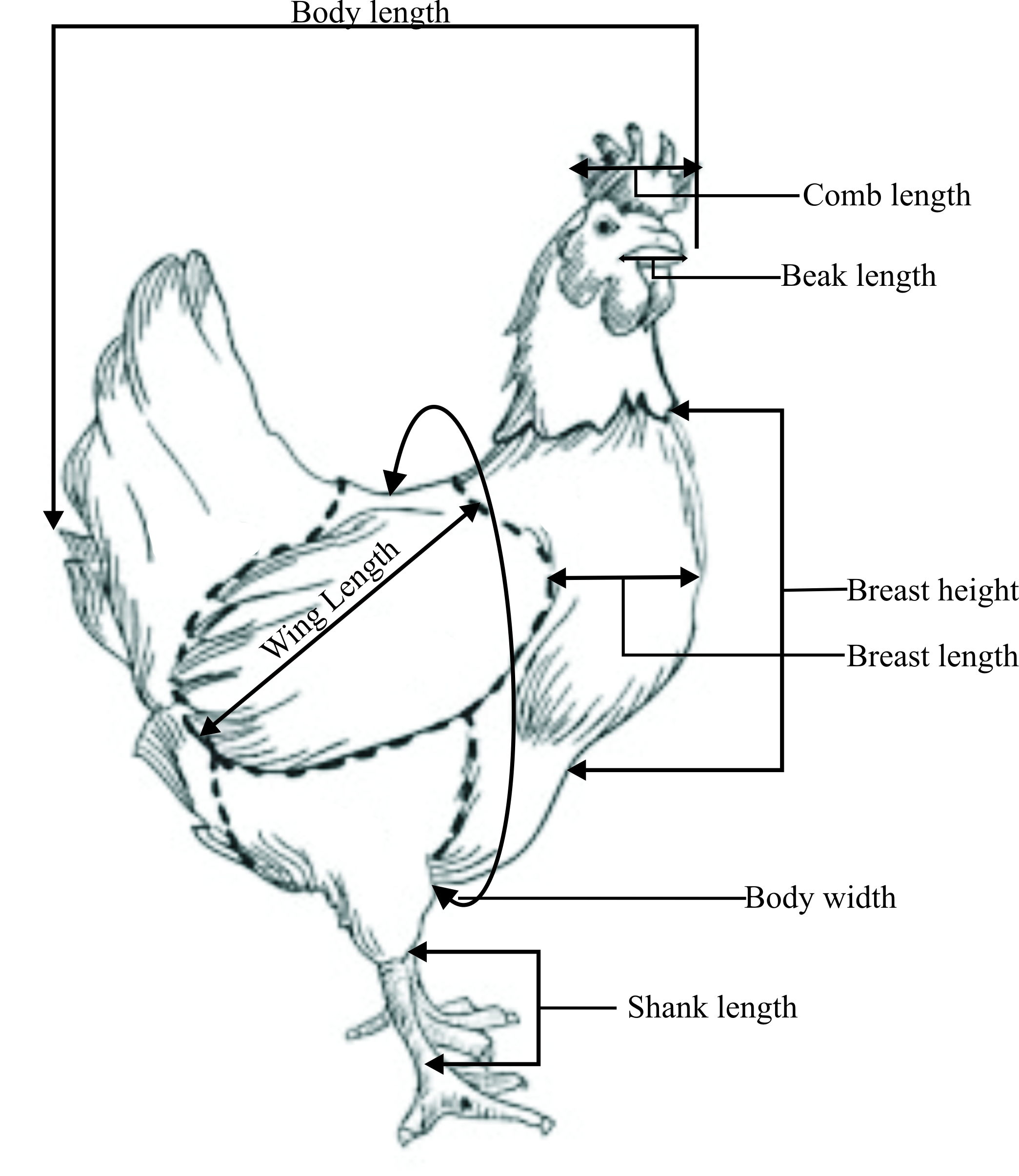


Plate III: Measurements of body parts in chickens.

**Source: Adekoya *et al.* (2013)**

Plumage, shank, beak, comb, eye, ear lobe, skin colours and types were observed visually.

Data on productivity parameters were obtained from questionnaires as follows:

Age at first egg - the number of days from hatch to the day the first egg was laid provided a second egg was laid in the next ten days.

Clutch size - the total number of eggs laid by indigenous chicken per clutch

Hatchability - the total number of eggs hatched to the total number incubated

(Eh / Ei) x 100

Where:

Eh = Total number of eggs hatched

Ei = Total number of eggs incubated.

Clutch Number - the number of laying cycle per year.

Mortality (chick) - the total number of hatched or weaned chicks that died.

Egg characteristics were determined as follows:

Egg colour - This was carried out by visual observation and the use of colour chart

Egg weight - Measured using a sensitive platform scale in grammes to two decimal

places.

Egg length - was determined as the distance between the two ends using a Vernier

caliper.

Egg width - Measured as the diameter at the broadest part of the egg using a

Vernier caliper.

Egg shell weight- The egg was broken and the shell, excluding membrane, immediately weighed in grammes using a sensitive scale.

Shell thickness - Measured, excluding the shell membrane, in grammes using a digital

micrometer screw gauge.

Internal egg characteristics were taken as follows:

Albumen width - The albumen was carefully separated and the width measured in

millimetres on a tripod using a micrometer screw gauge.

Albumen height - The content of the egg was poured into a plate and measured on a tripod micrometer screw guage (calibrated in mm)

Yolk width - The yolk was carefully separated and measured in millimetre on a

tripod using micrometer.

The Haugh Unit (HU) value was estimated from the relationship:

HU= log (H + 7.73- 1.7W0.36) 100 - - - - - (1)

Where H= albumen height W= egg weight (Haugh, 1937)

Common poultry diseases were assessed to determine their prevalence.

|  |  |  |
| --- | --- | --- |
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**3.5 On- Station Management and Data Collection**

Sixty two indigenous chickens of different strains which consisted of males and females were sampled from each of the states. The chickens were maintained as a single unselected and unimproved mating population and managed in an open sided poultry house screened with wire mesh for protection. They were allowed to mate, lay and hatch naturally.

Hatched chicks at day-old were vaccinated against Newcastle disease, using Hitchner Booster 1 (HB1) and LaSota(R) vaccines in accordance to recommendations by a veterinarian. At day 45, all the chickens were again vaccinated against Fowl typhoid. Chicks were weighed by type using a sensitive scale. They were placed on dry grass deep litter pens and light provided 24 hours starting at day-old and decreased at weekly intervals to natural day length at 20 weeks of age. All experimental chickens were offered standard starter and finisher rations, and water *ad libitum*. During the growth and laying phases, chickens were treated with Coccidiostat (Coccimed and Amprolium) and, Oxytetravit and Oxtetracycline against Infectious coryza and *Escherichia coli.* In addition, Pantominovit was given in water as vitamin supplement. In general, antibiotics and vitamins were supplied for all chicken flocks when disease was suspected. The first generation eggs were weighed and adult birds were measured for body characteristics and evaluation of external and internal egg qualities was performed on On- station chicken population as outlined for out- station methods.

**3.6 Statistical Analysis**

Non measureable data were classified into different categories, percentages calculated and chi-squares (χ2) were used to test the significance of proportion.

Where:

χ2 = (O – E)2 / E. - - - - - - - - - (2)

O = Observed values

E = Expected values

Linear measurements, productivity parameters and egg characteristics were also subjected to analysis of variance according to the different non measureable characteristics observed as follows:

**Yij =** μ**+ Sti + Sij+Sek+Pll+Ecm+Scn+Clo+Shp+Blq+Ecr+eijklmnopqr** - - (3)

Where;

Yij = an observation on variables.

μ = overall population mean.

Sti= effect of strain.

Sij= effect of site.

Sek= effect of sex.

Pll= effect of plumage.

Ecm = effect of eye colour.

Scn= effect of skin colour.

Clo= effect of comb colour.

Shcp= effect of shank colour.

Bkcq= effect of beak colour.

Ecr= effect of ear lobe colour.

eijklmnopqr = residual error (Assumed to be randomly, independently and normally distributed with mean equal to zero).

However because of the number of variables involved leading to co - linearity, only one way analysis was carried out. For example:

**Yij =** μ**+ Pli+eijk. - - - - - - - -** (4)

Where;

Yij = an observation on variables.

μ = overall population mean.

Pll = an independent variable

eijk = residual error (Assumed to be randomly, independently and normally distributed with mean equal to zero).

Significantly different means in a subset were separated using the Duncans Multple Range and Ryan Einot Gabriel Welsch F- Tests in Statistical package for Social Sciences SPSS Version 17 (2008). Pearson’s Correlation co- efficient was computed to test the relationship within and between body traits and egg parameters.

**CHAPTER FOUR**

**4.0 RESULTS**

**4.1 Socio- Economic Characteristics of Indigenous Chicken Farmers**

***4.1.1 Level of education, sex occupation age and marital status of farmers***

Table 7 presents the socio-economic characteristics of indigenous chicken farmers in the study area. Overall, 73% of the indigenous chicken farmers were females and 64.9% had no formal education. Those that kept solely indigenous chickens were 51.48% of the population. Some were traders 29.2%, civil servants 10.2%, farmers/traders 6.16% and civil servant/traders 3%. The majority of indigenous chicken farmers were above 50 years (51.2%) of age. For marital status, 86.08% of the farmers were married. Chi- squares values showed significant differences in most of the socio- economic characteristics namely education, marital status (P< 0.001), farmers’ occupation and age (P< 0.01).

***4.2* Major cultivated crops**

The percentage of farmers that cultivated various crops are shown in Table 8. Overall 41.68% cultivate cassava, 39.76% yam, 40.28% rice, 42.68%, maize and 31.08% cowpea. Others were okra (10%), soybean (4.84%), groundnut (12.8%), Sesame (6.12%), cocoyam (14.28%) and soya bean (5.1%).

**4.3 Management Systems**

The different chicken management procedures carried out in the study area are as in Table 9.

Table 7: Percentages of socio – economic characteristics of indigenous chicken farmers in the study area

State Sex Education Occupation Age Marital status

Male Female Formal Informal Farming Trading Civil service Farming/Trading Civil/Trading <18 <18-49 > 50 Married Not Married

Benue 23.8 76.2 36.0 64.0 48.2 32.8 8.6 6.2 4.2 30 18 52 82 18

Kogi 26.6 73.4 31.0 69.0 46.6 24.8 15.8 9.8 3.0 35.8 20.4 43.8 63 37

Nas. 29.6 70.4 30.4 69.6 71.8 20.4 4.2 2.4 1.2 33 15.2 51.8 97 3.0

Niger 30.0 70.0 27.6 72.4 60.2 21.6 9.8 5.8 2.8 34.4 21.8 43.8 92.4 7.6

Abuja 25.0 75.0 50.6 49.4 30.6 46.4 12.6 6.6 3.8 19.0 16.4 64.6 96 4.0

Mean 27.0 73.0 35.12 64.88 51.48 29.2 10.2 6.16 3.00 30.38 18.36 51.2 86.08 13.92

χ2 5.33 1.96 47.86 25.91 93.03 80.29 37.02 22.41 8.89 29.90 8.15 28.32 46.87 289.84

LS ns \*\*\* \*\* \*\* \*\*\*

df=4 df=4 df=16 df=8 df=4

Note:Nas. = Nasarawa. ns = not significant. Significant at \*\* = (P< 0.01), \*\*\* = (P< 0.001)

Table 8: Distribution (%) of crops cultivated by indigenous chicken farmers by state

StateCrops Cultivated %

Cassava Yam Rice Maize Cowpea Okra Sorghum G/nut Sesame C/yam S/bean

Benue 50.2 45.8 26.0 29.6 19.4 7.0 15.8 10.2 11.2 14.6 11.0

Kogi 48.0 24.6 30.8 42.4 33.2 14.6 19.4 16.2 11.4 15.2 9.0

Nasarawa 54.2 62.2 49.2 37.6 32.0 15.8 19.0 7.6 2.4 23.2 0.4

Niger 29.8 29.8 52.0 50.6 40.8 6.2 42.4 13.4 2.8 5.0 1.6

Abuja 26.2 37.4 43.4 53.2 30.0 6.4 27.6 16.6 2.8 13.4 3.6

Mean 41.68 39.96 40.28 42.68 31.08 10.00 24.84 12.8 6.12 14.28 5.1

Percentages add up to more than 100% because farmers cultivated more than one crop.

Note: G/nut (Groundnut), C/yam (Cocoyam), S/bean (Soyabean)

Majority of farmers keep chicken extensively (57.8%). However the percentages vary widely between and within states. Daily cleaning of poultry houses was carried out by only 3.4% of farmers, weekly 24.9%, monthly 18.6% and more than monthly 47.9%. Birds on scavenged feed resource constituted 73.2% in the area, while only 26.72% received supplementary feeds. Majority of farmers 68.44% do not supply water frequently. Chi- squares values showed significant differences in housing, sanitation, feeding (P< 0.01), and watering (P< 0.001).

**4.4 Flock Structure**

Flock structure (Table 10) revealed overall proportion of 28, 21.4, 23.2 and 27.5% for cock, hen, growers and chick respectively. Chi-square showed significant difference (P <0.001) between states. Cock population was highest 38.13, 33.99, and 30.25% in Benue, Kogi and Nasarawa. However, chick and grower populations were highest in Niger and Abuja with values of 29.16 and 28.84% respectively. Chi-squares tests revealed significant (P<0.001) percentage variation within states.

**4.5 Common Disease Prevalence**

Table 11 presents the prevalence of some common diseases in the study area. Newcastle disease was the most prevalent 63.22%; this was also true for all the state. Prevalent rate for Newcastle vary between 59.2% to 73.20% in Abuja and Benue respectively. The highest incidence of Coccidiosis 32.0% was in Niger and the least 20.20% in Kogi state. Incidences of Chronic respiratory diseases were low in all states, with 10.3% in the entire population. Fowl pox (2.5%) and Fowl cholera (0.87%), were even lower. Chi-squares tests revealed significant (P<0.001) percentage variation within states.

Table 9: Percentages of farmers practising various management systems in the study area

State Housing Sanitation Feeding Watering

Semi –Int, Ext. Daily wkly monthly >monthly Scavenged Supplements Frequent Not frequent

Benue 51.2 48.8 1.2 20.8 16.6 61.4 80.6 19.4 40.4 59.6

Kogi 48.6 51.4 1.0 16.4 12.6 70.0 79.8 20.2 16 84

Nasarawa 25.8 74.2 0.4 13.4 23.6 58.6 81.8 18.2 16.8 83.2

Niger 36.2 63.8 2.0 11.2 25 39.8 75.8 24.2 65 35

Abuja 49.2 50.8 12.4 62.6 15.2 9.8 48.4 51.6 73.6 26.4

Mean 42.2 57.8 3.4 24.9 18.6 47.9 73.28 26.72 31.56 68.44

χ2 13.70 \*\* 12.4 19.4 12.2 24.2 \*\* 18. 7 22.6 \*\* 14.9 33.2 \*\*\* 29.6

df = 4 12 4 4

Significant at \*\* (P< 0.01), \*\*\* (P< 0.001)

Note: Semi- int. (Semi-intensive), Ext. (Extensive), wkly (weekly).

Table 10: Flock structure (%) by state

Variable Benue Kogi Nasarawa Niger Abuja Total χ2 LS df4

Cock 38.13 33.99 30.25 21.58 21.03 28.0 678.394 \*\*\*

Hen 22.74 19.70 16.79 23.34 23.84 21.3 153.003 \*\*\*

Growers 18.73 16.47 22.77 25.92 28.84 23.2 370.643 \*\*\*

Chickens 20.40 29.64 30.25 29.16 26.29 27.5 180.018 \*\*\*

Total 15.6 17.0 21.2 23.1 23.2 100 1382.058 \*\*\*

χ2 436.843\*\*\* 262.244\*\*\* 132.927\*\*\* 206.278\*\*\* 343.766\*\*\*

df= 3 \*\*\* = significant at P<0.001. Figures are percentages

Table 11: Disease prevalence

% Incidence per State

Diseases Benue Kogi Nasarawa Niger Abuja Total χ2 LS df4

Newcastle 366 (73.20) 312 (62.4) 301 (60.20) 296 (59.20) 312 (62.40) 1587 (63.22) 81.22 \*\*\*

Coccidiosis 102 (20.40) 101 (20.20) 102 (20.40) 160 (32.00) 114 (22.80) 579 (23.06) 16.71 \*\*\*

Chronic Respiratory Disease 20 (4.00) 66 (13.20) 70 (14.00) 51 (10.20) 52 (10.40) 259 (10.32) 31.32 \*\*\*

Fowl Pox 10 (2.00) 18 (3.60) 14 (2.80) 02 (0.40) 19 (3.80) 63 (2.51) 26.75 \*\*\*

Fowl Cholera 02 (0.40) 03 (0.60) 13 (2.60) 01 (0.20) 03 (0.60) 22 (0.87) 28.97 \*\*\* Figures in parenthesis are percentages

**4.6 Non - measureable chicken characteristics**

***4.6.1 Normal chickens and other variations due to major genes***

The prevalences of single major gene traits are presented in Table 12. Majority of birds in the study area, 89.78% had normal feathering. Between the states results indicated that Normal feathering ranged from 17.84 to 24.61% in Niger and Nasarawa respectively. Percent frizzled ranged from 0.31 to 0.53% in Benue and Abuja with an overall average of 1.46%. Silky feathering and dwarf legged chickens were 0.53 and 0.68% in the population. Chi-square values were significant (P<0.01, P<0.001) for strains studied.

**4.7 Comb type distribution**

The different comb types are presented in Table 13. Of the 6176 chickens observed 5305 (85.90%) were single combed, 595 (9.63%) pea, 181(2.93%) rose and 95(1.54%) walnut. Chi-square values showed that there were significant differences (P <0.01) in comb-type distributions. In Benue, pea comb occurrence (20.67%) was highest followed by single (18.87%), walnut (17.89%) and rose (9.39%). Kogi, comb distribution were; rose (28.73%), walnut (21.05%), single (19.23%) and pea (17.48%) respectively. Nasarawa had rose comb (36.46%), walnut (32.63), pea (28.74%) and single (23.60%). Niger had walnut (23.16%), single (19.81%), pea (17.82%) and rose (18.60%), while Abuja also had single (18.49%) highest, pea (15.29%), rose (13.81%) and walnut (5.26%). Chi-squares test revealed significant percentage variations for pea and walnut (P <0.01), rose and single (P <0.001) by state. Similarly, significant (P <0.01) percentage variations were also observed in all state except Kogi.

Table 12: Single major gene traits in the chicken population within the study area

State Naked neck Fizzle Silky Dwarf Normal Total

Feathered Feathered Legged Feather No. of birds χ2 df4

Benue 155 (2.51) 23 (0.37) 6 (0.09) 17 (0.27) 957 (15.49) 1158 (18.75) 70.86\*\*\*

Kogi 123 (1.99) 14 (0.22) 7 (0.11) 3 (0.05) 1049 (16.98) 1196(19.40) 16.09 \*\*\*

Nasarawa 88 (1.42) 9(0.14) 4 (0.06) 2 (0.03) 1417 (22.94) 1520(24.61) 25.08 \*\*\*

Niger 22 (0.36) 11 (0.17) 10 (0.16) 12 (0.19) 1145 (18.54) 1200(19.43) 62.767\*\*\*

Abuja 80 (1.29) 33 (0.53) 6 (0.09) 8 (0.13) 975 (15.79) 1102(17.84) 18.225 \*\*\*

Total 468(7.58) 90 (1.46) 33 (0.53) 42 (0.68) 5543 (89.75) 6176(100)

χ2 121.92\*\*\* 30.98\*\*\* 41.66\*\*\* 22.37\*\*\* 13.61\*\* 194.207 \*\*\*

Df4

Significant at \*\* = (P< 0.01), \*\*\* = (P< 0.001). Figures in parenthesis are percentages of grand total

Table 13: Comb types by state

Types Benue Kogi Nasarawa Niger Abuja Total χ2 LS df4

Pea 20.67 17.48 28.74 17.82 15.29 595(9.63) 22.1 \*\*

Rose 9.39 28.73 36.46 11.60 13.81 181(2.93) 33.0 \*\*\*

Single 18.87 19.23 23.60 19.81 18.49 5305(85.90) 44.2 \*\*\*

Walnut 17.89 21.05 32.63 23.16 5.26 95 (1.54) 13.9 \*\*

Total 18.75 19.37 24.61 19.43 19.43 100

χ2 17.2\*\* 5.2ns 11.5\*\* 12.3\*\* 13.0\*\*

df=3. Significant at \*\* = (P<0.01), \*\*\* = (P<0.001). Figures are percentages of grand total



Plate IV: Single comb type and mottled plumage colouration.

**4.8 Colour variation in indigenous chickens**

Chi-squares test revealed significant (P <0.01, P <0.001) percentage variation in individual plumage colours (except white and brown) by state (Table 14). Similarly significant (P <0.01) percentage colour variations were observed for Benue, Kogi, Nasarawa, Niger and Abuja. Overall, brown plumage was highest (19.81%) followed by black and white (19.69%), black (19.43%), black/ brown (15.83%), mottled (15.15%) and the least was white (10.07%). Plumage distribution in Benue and Kogi state favoured black (22.5%) and (22.8%) respectively. Nasarawa recorded black/ brown (38.2%) as predominant colour. Niger and Abuja had white (21.9%), and (23.5%) as dominant colours respectively.

Chi-squares test revealed significant (P <0.001) percentage variation in individual shank colours (P <0.001) except yellow (Table 15). Similarly significant percentage shank colour variations were observed for Benue, Niger (P <0.001) and Abuja (P <0.01). Most chicken shanks in Kogi and Nasarawa were black 22.68 and 26.94% respectively (Table 15). White shanks were dominant in Benue 22.99% and Niger 24.64%. Beak colour was found to be mostly black in Benue 20.35%, Niger 20.62% and Abuja 19.16%. Nasarawa had yellow beak 30.68% as dominant colour (Table 15). Chi-squares test revealed significant percentage variation in black (P <0.01) white and yellow (P <0.001) beaks by state. Similarly significant percentage skin colour variations were observed for Benue, Nasarawa (P <0.001) and Abuja (P <0.01) (Table16). White skinned chickens were highest in percentages 70.81, 71.51, 72.96, 73.23 and 83.41% in Benue, Kogi, Nasarawa, Abuja and Niger respectively. Combs and ear lobes were mostly red with similar percentages which ranged from 72.6% in Abuja to 99.67% in Kogi state. However, eye colour was mostly yellow and also had similar range between 72.6% in Abuja to 99.67% in Kogi state.



Plate V: Dominant brown plumage



Plate VI: Dominant red comb, ear lobe and yellow eye colour.



Plate VII: Common beak and shank colours

1. Black beak and shank colour b. Yellow beak and shank colour

Chi-squares test for skin colour revealed significant percentage variation in all state except Benue. Similarly significant (P <0.01) percentage comb colour variations were also observed in all state except in Benue. Ear lobe colour was also significant (P <0.001) in all states however eye colour showed significant (P <0.01) difference in all states except Niger. Egg colour was mostly brown and ranged from 52.56 to 64.97% in Benue and Kogi state. Cream also ranged from 13.32 to 20.96% in Nasarawa and Niger state, while white eggs ranged from 15.88 to 26.80% in Abuja and Benue state respectively. Overall, brown egg shell colour was highest 58.99%, white 21.27% and cream 19.74%. Chi-squares tests revealed significant (P <0.001) percentage variation in all states.

**4.9 Linear body measurements**

***4.9.1 Body weight***

The overall mean mature body weight of indigenous chicken for outstation in the study area (Table 17) was 1.88±0.01kg. Body weights varied significantly (P<0.01) by state, while Benue state had a higher weight (1.95±0.01kg) the others had lower values of 1.89 ± 0.01, 1.87±0.01, 1.88 ± 0.01 and 1.85±0.01kg respectively which were not significantly different. Body weight also varied significantly (P<0.001) by sex between states (Table 18). The values for males varied from 2.11±0.02 in Nasarawa to 2.22±0.02kg in Benue. For females it varied from 1.55 ± 0.01 in Kogi to 1.69±0.02kg in Benue. The on-station had a mean body weight of 1.88±0.01kg which varied significantly by sex with male and female values of 2.19 ± 0.01 and 1.55 ± 0.01kg respectively.

Table 14: Plumage colour distribution (%) by state

Plumage Benue Kogi Nasarawa Niger Abuja Total χ2

Black 22.5 22.8 18.7 17.8 18.2 1200(19.43) 31.7\*\*\*

White 6.4 0 16.4 31.8 21.9 23.5 622(10.07) 10.3 ns

Black/White 20.9 21.5 23.2 20.4 14.0 1216(19.69) 34.3\*\*\*

Brown 18.8 17.8 21.2 20.6 21.6 1224(19.82) 8.52 ns

Black/Brown 18.2 15.7 38.2 16.0 11.9 978(15.83) 22.9\*\*

Mottled 19.9 19.9 19.4 20.7 20.1 (936) (15.16) 41.9\*\*\*

Total 18.8 19.4 24.6 19.4 17.8 6176(100)

χ2 64.22\*\*\* 21.24\*\*\* 121.52 \*\*\* 11.93\*\* 50.40\*\*\*

df = 5. Figures are percentages Significant at \*\* = (P< 0.01), \*\*\* = (P<0.001)

Table 15: Shank and beak colour distribution (%) by state.

Body Parts

Shank Beak

Colours Benue Kogi Nasarawa Niger Abuja Total χ2 Benue Kogi Nasarawa Niger Abuja Total χ2

Black 16.73 22.69 26.94 17.20 16.37 62.5 44.2\*\*\* 20.35 19.00 20.89 20.62 19.16 60.01 13.6\*\*

White 22.99 12.32 21.68 24.64 18.36 27.33 23.4\*\*\* 14.05 20.60 29.88 17.74 17.74 23.7 30.2\*\*\*

Yellow 19.48 17.83 18.15 19.11 25.48 10.17 9.0 ns 19.72 18.92 30.68 17.53 13.15 16.2 23.2\*\*\*

Total 18.75 19.37 24.61 19.43 17.84 100 18.75 19.37 24.61 19.43 17.84 100

χ2 38.7\*\*\* 10.2ns 9.60ns 18.7\*\*\* 12.2\*\* 22.79\*\*\* 1.52ns 52.43\*\*\* 6.71ns 16.09\*\*

Figures are percentages significant at\*\* = (P< 0.01) \*\*\* (P<0.001)

Table 16: Observable characteristics for skin, comb, ear lobe, eye and egg colour distribution

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| State | | | | | | |
| Colours | Benue | Kogi | Nassarawa | Niger | Abuja | Total |
| Skin colour |  |  |  |  |  |  |
| Black | 1.99 | 3.34 | 3.62 | 0.17 | 0.36 | 124 (2.00) |
| White | 70.81 | 71.57 | 72.96 | 83.41 | 73.23 | 4593 (74.4) |
| Yellow | 27.20 | 25.05 | 23.42 | 16.42 | 26.41 | 1459 (23.6) |
| Total | 100 | 100 | 100 | 100 | 100 | 6176 |
|  | 8.25ns | 12.98\* | 20.07\*\* | 59.85\*\*\* | 18.65\*\* | 119.80\*\*\* |
| Df = 2 |  |  |  |  |  |  |
| Comb Colour |  |  |  |  |  |  |
| Red | 86.44 | 99.67 | 93.42 | 75 | 72.60 | 5313 (86.03) |
| Redish pink | 13.56 | 0.33 | 6.58 | 25 | 27.40 | 863 (13.97) |
| Total | 100 | 100 | 100 | 100 | 100 | 6176 |
|  | 0.166ns | 185.08\*\*\* | 69.14\*\*\* | 121.374\*\*\* | 165.38\*\*\* | 541.14\*\*\* |
| Df = 1 |  |  |  |  |  |  |
| Ear lobe colour |  |  |  |  |  |  |
| White | 0.60 | 0.17 | 2.63 | 8.33 | 9.26 | 251 (4.06) |
| Red | 86.44 | 99.66 | 93.42 | 75 | 72.60 | 5313 (83.03) |
| Brown | 12.95 | 0.17 | 3.95 | 16.67 | 18.15 | 612 (9.91) |
| Total | 100 | 100 | 100 | 100 | 100 | 6176 |
|  | 44.95\*\*\* | 185.10\*\*\* | 71.86\*\*\* | 126.07\*\*\* | 171.69\*\*\* | 599.68\*\*\* |
| Df = 2 |  |  |  |  |  |  |
| Eye colour |  |  |  |  |  |  |
| Yellow | 86.44 | 99.66 | 93.42 | 75 | 72.60 | 5313 (83.06) |
| Red | 0.60 | 0.17 | 2.63 | 8.33 | 9.26 | 251 (4.06) |
| Brown | 12.95 | 0.17 | 3.95 | 16.67 | 18.15 | 612 (9.91) |
| Total | 100 | 100 | 100 | 100 | 100 | 6176 |
|  | 9.70\*\* | 9.48\*\* | 19.06\*\* | 7.57ns | 13.48\*\* | 59.31\*\*\* |
| Df = 2 |  |  |  |  |  |  |
| Egg colour |  |  |  |  |  |  |
| Brown | 52.56 | 64.97 | 58.22 | 59.27 | 59.13 | 2968(58.99) |
| Cream | 20.64 | 13.32 | 17.59 | 20.96 | 24.98 | 993(19.74) |
| White | 26.80 | 21.70 | 24.19 | 19.76 | 15.88 | 1070( 21.27) |
| Total | 100 | 100 | 100 | 100 | 100 | 5031 |
|  | 44.25\*\*\* | 162.01\*\*\* | 58.2\*\*\* | 119\*\*\* | 48.7\*\*\* | 432.2\*\*\* |
| Df = 2 |  |  |  |  |  |  |

Number in parenthesis are percentages. Significant at \*\* = (P<0.01); \*\* \*= (P<0.01)

***4.9.2 Body length***

The overall mean body length (Table 17) for out- station study was 19.36± 0.02cm. There was no significant difference in body lengths by state. However, body length within state by sex (Table 18) showed that males had significantly (P<0.001) longer bodies than females in all states. The largest female was observed in Kogi state (18.39±0.10cm) while the shortest were in Nasarawa (18.19±0.03 cm). Similarly the longest and shortest males were found in Nasarawa (20.47±0.08cm) and Benue (20.38±0.09cm) respectively. The overall on station body length was 19.245±0.069cm while those of males and female were 20.38±0.09 and 19.08±0.09cm respectively.

***4.9.3 Body width***

The average mature body width for the entire population was 18.25 ± 0.01cm. Body width was significantly (P<0.01) different by states. Males were significantly (P<0.001) wider than females (Table 18). Body width for males in Nasarawa varied from 18.59 ± 0.08 to 18.82± 0.10cm in Kogi state. It also varied from 17.83±0.07 in Nasarawa to 17.93 ± 0.08cm in Abuja in female. The on-station had a mean body width of 18.11±0.05cm but varied significantly by sex with male and female values of 17.99±0.23 and 18.13 ± 0.08cm respectively.

***4.9.4 Shank length***

The overall mean out station shank length was 9.39± 0.03cm. The overall on-station value was 9.31±0.10cm while those of males and female were 9.26±0.45 and 9.31±0.16cm respectively. There was no significantly difference (Table 17) by state. However, there was a significant (P<0.001) difference by sex (Table 18). The highest length was recorded in Nasarawa state (9.64± 0.08) and the least (9.32±0.03cm) in Abuja. The longest females in shank were also observed in Nasarawa state (9.56±0.18 cm) while the shortest were in Abuja (9.09 ± 0.17 cm). Similarly the longest and shortest shanks in male were found in Kogi and Abuja (9.84±0.17 and 9.52 ± 0.16) respectively.

***4.9.5 Wing length***

Overall wing length (Table 17) was 14.23± 0.03cm for out station and 14.33±0.10cm for on station; Males had longer wings 15.34±0.03 than females 14.20±0.11cm at out station.

There was significant (P<0.001) difference in wing length by state. There was also significant (P<0.001) difference by sex (Table 18). Birds varied from 13.99±0.07 to 14.38±0.07cm in Benue and Abuja respectively. The highest length observed in males was 15.18 ± 0.11cm in Abuja and the least was in Benue and Kogi (14.68±0.17). For females it was also highest in Abuja (13.56 ± 0.12cm) and lowest (13.28±0.17cm) in Kogi.

***4.9.6 Beak length***

The mean overall beak length (Table 17) for out- station study was 3.12±0.01cm. Beak length did not differ significantly by states. However, there was significant (P<0.001) difference by sex (Table 18). Males had longer beaks (3.36±0.01) than females (2.92±0.01cm). The longest (3.38±0.02) was recorded in Abuja and the shortest (3.33±0.02) in Benue. The overall at on-station was 3.09±0.01cm while those of males and females were 3.37±0.07 and 3.05±0.02cm respectively.

***4.9.7 Comb length***

Overall comb length (Table 17) for out station was 2.64±0.01cm. Comb length was not significantly different by state but varied (P<0.001) by sex (Table 18). Highest comb length (2.66±0.02cm) was recorded in Abuja and least (2.64±0.02cm) in Benue. Comb lengths varied in males in Benue from 3.14±0.02 to 3.17 ± 0.01cm in Niger state. It also varied from 2.12 ± 0.01cm in Niger to 2.15±0.02cm in Kogi for females. The on-station had a mean comb length of 2.58 ± 0.02cm which varied significantly by sex with male and female values of 3.17 ± 0.09cm and 2.50 ± 0.03cm respectively.

***4.9.8 Breast height***

Overall breast height recorded was 11.60± 0.33cm. Breast height (Table 17) was not significantly different by state but differ significantly (P<0.001) by sex (Table 18). Mean heights varied from 11.54±0.07 to 11.70±0.08cm in Abuja and Kogi respectively. Kogi also recorded highest breast (12.34±0.08cm) in male and the least (12.10±0.06cm) was observed in Nasarawa. Males generally had higher breast than females. The highest value (11.02±0.08 cm) in female was observed in Kogi and the least (10.91 ± 0.05cm) in Niger. Values for on-station were 11.81 ± 0.09, 12.20 ± 0.99 and 11.38 ± 0.35cm for overall, males and females respectively.

***4.9.9 Breast length***

The overall breast length showed a mean value length of 18.05±0.02cm for out station and 18.00±0.05cm for on station which varied significantly by sex with male and female values of 18.35 ± 0.23 and 17.96 ± 0.08cm. Breast length (Table 17) was not significantly different by state but differed (P<0.001) by sex(Table 18). The longest breast (18.17 ± 0.04cm) was recorded in Abuja and the shortest (18.03±0.04cm) in Benue state. The longest breast in female (17.66 ± 0.08cm) was observed in Niger while the least (17.56±0.09 cm) was in Kogi. On the other hand the longest male breast (18.56 ±0.09) was recorded in Kogi and the shortest was in Abuja (18.46 ± 0.08cm).

**4.10 Egg Quality Characteristics**

***4.10.1 External quality***

Egg weights of indigenous chickens at out-station and on station are presented in Tables 19 and 20 and, the mean value of 39.59 ±0.06g did not vary significantly. There was however significant variation by state with highest (39.86g) and lowest (39.32 values in Nasarawa and Kogi respectively. Overall mean egg length for out- stationwas 3.80±0.01, while on-station had 3.81cm. The egg length values were not significantly different by site and state. Overall mean egg width forout-station of 3.89 ± 0.01cm and on-station 3.88± 0.01cm, were similar but values varied significantly (P<0.01) by states. The highest width (3.95 was observed in Benue and the least (3.84in Nasarawa. Overall mean shell thickness was 0.90±0.32mm at out-station while on-station value was 0.52±0.05mm. There was no significant difference in shell thickness by site but it was significant (P<0.001) by state. Thickness varied from 0.35±0.03 to 0.790±0.08mm in Nasarawa and Niger respectively. Shell weight was observed to be 4.18± 0.01 and 4.16± 0.01g for out/ on stations respectively; and showed non significant difference by site and state.

Table 17: Linear body measurement by State (cm)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mean Standard Error | | | | | | | | |
| State | | | | | | | | |
| Parameter | Benue | Kogi | Nassarawa | Niger | Abuja | Overall | On-station | LS |
| Body weight (kg) | 1.95 ± 0.01a | 1.87 ± 0.01b | 1.85 ± 0.01b | 1.89 ± 0.01b | 1.88 ± 0.01b | 1.88 ± 0.01 | 1.88 ± 0.01b | \*\* |
| Bodylength(cm) | 19.34 ± 0.05 | 19.43 ± 0.59 | 19.35 ± 0.52 | 19.39 ± 0.05 | 19.40 ± 0.05 | 19.36 ± 0.02 | 19.24 ± 0.06 | NS |
| BodyWidth(cm) | 18.25 ± 0.04ab | 18.39 ± 0.04a | 18.20 ± 0.04ab | 18.24 ± 0.04ab | 18.27 ± 0.04ab | 18.25 ± 0.01 | 8.11 ± 0.05b | \*\* |
| Shanklength (cm) | 9.34 ± 0.09 | 9.38 ± 0.09 | 9.64 ± 0.08 | 9.37 ± 0.08 | 9.32 ± 0.08 | 9.39 ± 0.03 | 9.31 ± 0.10 | NS |
| Winglength(cm) | 3.99 ± 0.07b | 13.99 ± 0.07b | 14.35 ± 0.07a | 14.33 ± 0.07a | 14.38 ± 0.07a | 14.23 ± 0.03 | 14.33 ± 0.08a | \*\*\* |
| Beaklength(cm) | 3.10 ± 0.16 | 3.12 ± 0.01 | 3.14 ± 0.01 | 3.15 ± 0.01 | 3.14 ± .015 | 3.12 ± 0.01 | 3.09 ± 0.01 | NS |
| Comblength(cm) | 2.64 ± 0.02 | 2.65 ± 0.02 | 2.66 ± 0.02 | 2.66 ± 0.02 | 2.66 ± 0.02 | 2.64 ± 0.01 | 2.58 ± 0.02 | NS |
| BreastHeight(cm) | 11.56 ± 0.08 | 11.70 ± 0.08 | 11.54 ± 0.07 | 11.52 ± 0.07 | 11.54 ± 0.07 | 11.60 ± 0.33 | 11.81 ± 0.09 | NS |
| Breastlength(cm) | 18.03 ± 0.04 | 18.06 ± 0.04 | 18.06 ± 0.04 | 18.07 ± 0.04 | 18.17 ± 0.04 | 18.05 ± 0.02 | 18.00 ± 0.05 | NS |

LS = Levels of Significant. NS= Not Significant (\*\* = P<0.01, \*\*\* = P<0.001) Means in row with different superscripts are significantly different.

Table 18: Linear body measurement by sex (cm)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mean Standard Error | | | | | | | | |
| Parameter | Overall Per Sex | Benue | Kogi | Nassarawa | Niger | Abuja | On- Station | LS |
| Body weight | M 1.88±0.01a | 2.22±0.01a | 2.19± 0.01a | 2.11±0.01a | 2.19±0.01a | 2.19±0.01a | 2.19+0.01a | \*\*\* |
|  | F 1.67±0.01b | 1.69±0.01b | 1.55±0.01b | 1.60±0.01b | 1.59±0.01b | 1.55±0.01b | 1.55+0.00b |  |
| Body length | M 20.43a | 20.380.01a | 20.430.09a | 20.470.08a | 20.420.08a | 20.420.08 a | 20.50 0.02a | \*\*\* |
|  | F 18.450.02b | 18.260.09b | 18.39 0.10b | 18.19 0.03b | 18.31 0.09b | 18.310.09b | 19.08 0.09b |  |
| Body width | M 18.62a | 18.630.08a | 18.820.10a | 18.560.07a | 18.600.08a | 18.590.08a | 17.99 0.23a | \*\*\* |
|  | F 17.930.02b | 17.850.09b | 17.930.10b | 17.830.07b | 17.870.08b | 17.930.08b | 18.130.08b |  |
| Shank length | M 9.65a | 9.760.17a | 9.840.17a | 9.690.18a | 9.580.17a | 9.520.16a | 9.26 0.45a | \*\*\* |
|  | F 9.170.05b | 8.940.17b | 8.950.17b | 9.560.18b | 9.150.17b | 9.090.17b | 9.310.16b |  |
| Wing length | M 14.99a | 14.680.17a | 14.680.17a | 15.16.12a | 15.090.11a | 15.180.11a | 15.34 0.32a | \*\*\* |
|  | F 13.580.04b | 13.270.17b | 13.280.17b | 13.530.12b | 13.530.11b | 13.560.12b | 14.200.11b |  |
| Beak length | M 3.36a | 3.330.02a | 3.350.02a | 3.370.02a | 3.380.02a | 3.380.02a | 3.370.07a | \*\*\* |
|  | F 2.920.01b | 2.870.02b | 2.870.02b | 2.900.02b | 2.910.02b | 2.890.02b | 3.050.02b |  |
| Comb length | m 3.16a | 3.140.02a | 3.140.02a | 3.170.01a | 3.170.01a | 3.170.01a | 3.170.09a | \*\*\* |
|  | F 2.210.01b | 2.130.02b | 2.150.02b | 2.130.01b | 2.120.01b | 2.130.11b | 2.500.03b |  |
| Breast height | M12.25a | 12.140.06a | 12.340.08a | 12.100.06a | 12.110.05a | 12.110.05 | 15.20 0.99a | \*\*\* |
|  | F11.050.04b | 10.980.06b | 11.020.08b | 10.950.06b | 10.910.05b | 10.940.16b | 11.380.35b |  |
| Breast length | M18.48 | 18.490.09a | 18.560.09a | 18.490.08a | 18.4810.08a | 18.4680.08a | 18.35 0.23 a | \*\*\* |
|  | F17.6950.026b | 17.5710.097b | 17.5670.098b | 17.5790.087b | 17.6600.086b | 17.6570.088b | 17.9630.086b |  |

Note: M = Male F= Female LS, Levels of significant Ns, Not Significant (\*P<0.05, \*\* P< 0.01, \*\*\* P<0.001). Means in row with different superscripts are significantly different

***4.10.2 Internal quality***

Overall mean albumen width for out-station was 18.78 ± 0.02cm while that of on-station was 18.79m. There was no significant difference in albumen width by site and state Overrall mean albumen height was observed to be 4.57± 0.03cm at out- station while that of on- station was 4.71± 0.02cm and showed no significant difference by site but differed significantly (P<0.001) by state. It varied from 3.66 to 4.62cm in Kogi and Abuja respectively. The mean yolk width recorded for out-station was 12.76 ± 0.02cm and 12.75 ± 0.02cm for on- station, which showed a non significant difference by site and by state.The overall quality rating of the egg (Haugh unit) at out-station was 76.31± 0.16 while on-station value was 67.45± 0.11. There was significant difference (P<0.001) by site and by state. Highest egg quality (Hu=78.610.22) was observed in Nasarawa and least (Hu = 73.440.16) in Niger state.

**4.11 Productivity parameters**

The productivity parameters are presented in Table 21. Clutch size ranged from 10.84± 0.23 to 11.45 ± 0.23 in Abuja and Nasarawa respectively. On- station clutch size was 13.11 ± 0.23. There was significant difference (P<0.001) in clutch size by site while states had similar values. Number of eggs incubated ranged from 8.71±0.01to 11.38±0.32in Benue and Nasarawa state, which was significant (P<0.001) by location. Age at first egg, clutch number and hatchability did not vary significantly. However, there was significant difference (P<0.05) in chick mortality which ranged from 43.19 to 53.89% in Benue and Abuja. On-station mortality value stood at 26.78%.

**4.12 Relationship between body measurements**

Correlation coefficients between body measurements are presented in Table 22. All most all correlation values were positive and significant at 1%. A few were correlated at 5% with only one non significant value (0.007) between shank and beak length. The correlation values between body length to shank (0.90) and comb lengths (0.558) were high while the remaining values were medium to low

**4.13 Relationship between egg characteristics**

Correlation coefficients between egg measurements are presented in Table 23. Most correlation values were significant at 1%. Only egg weight is correlated with shell weight at 5 % (0.036; P<0.05). Most egg characteristic measured was lowly correlated. Albumen height is correlated with yolk width (0.389; P<0.01). There was no significant correlation between egg weight and shell thickness (-0.024) and albumen weight (-0.014). Egg length was not significantly affected by shell thickness (0.004) and shell weight (0.006).

**4.14** **Relationship between egg characteristics and production traits**

Table 24 presents the correlation coefficients between egg production traits of indigenous chickens.Most correlation values were significant at 1%. Only number of chicks hatched to number of egg wasted, egg width, egg length and mortality were correlated at 5 %. Most egg production traits are lowly correlated.

Table 19: Overall mean egg characteristics by site

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Out-Station | On-Station | LS | Combined Mean |
| Egg weight (g) | 39.59 | 39.690.05 | NS | 39.640.04 |
| Egg length (cm) | 3.80 | 3.810.01 | NS | 3.800.01 |
| Egg width (cm) | 3.890.01 | 3.88 0.01 | NS | 3.890.01 |
| Shell thickness(mm) | 0.900.32 | 0.77 | NS | 0.840.20 |
| Shell weight (g) | 4.180.01 | 4.170.01 | NS | 4.180.01 |
| Albumen width (cm) | 18.780.02 | 18.78 0.01 | NS | 18.780.01 |
| Albumen height (cm) | 4.570.03 | 4.610.02 | NS | 4.590.02 |
| Yolk width (cm) | 12.760.02 | 12.750.02 | NS | 12.750.01 |
| Haugh Unit | 76.310.16b | 67.450.11a | \*\*\* | 71.88.13 |

Note:- LS = Level of significant. NS = Not Significant.

Significant at \*\*\* = (P<0.001)

Table 20: Egg characteristics by state

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Benue | Kogi | Nasarawa | Niger | Abuja | Overal Mean Out- Station | On- Station | LS |
| Egg weight(g) | 39.41b | 39.320.16b | 39.860.15b | 39.730.15b | 39.500.15b | 39.560.18 | 39.86 0.05a | \*\*\* |
| Egg length(cm) | 3.78 | 3.780.01 | 3.790.01 | 3.810.01 | 3.820.01 | 3.800.01 | 3.81 0.01 | NS |
| Egg width(cm) | 3.95 | 3.890.02ab | 3.840.02a | 3.900.02ab | 3.890.02ab | 3.890.02 | 3.88 0.01a | \*\* |
| Shell thickness | 0.52b | 0.520.01b | 0.350.03a | 0.790.08b | 0.520.01b | 3.800.01 | 0.52 0.05b | \*\*\* |
| Shell weight(g) | 4.23 | 4.180.03 | 4.180.03 | 4.230.03 | 4.180.03 | 4.200.03 | 4.16 0.01 | NS |
| Albumen wi(cm) | 18.78 | 18.690.04 | 18.750.04 | 18.850.04 | 18.820.04 | 18.780.04 | 18.77 0.01 | NS |
| Albumen ht(cm) | 4.57a | 3.660.07b | 4.530.07a | 4.590.07a | 4.620.07a | 4.390.07 | 4.71 0.02a | \*\*\* |
| Yolk width(cm) | 12.75 | 12.710.06 | 12.790.06 | 12.780.06a | 12.760.05 | 12.760.05 | 12.75 0.02 | NS |
| Haugh Unit | 76.220.02a | 74.340.52a | 78.610.22a | 73.440.162a | 78.140.52a | 76.310.162 | 67.450.11b | \*\*\* |

Note:- Ns, not Significant, (\*\*\*P<0.001, (\*\*P<0.01) Means in a row with different superscripts are significantly different.

Where: wi = width, ht = height

Table 21: Productivity of indigenous chickens

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Benue Kogi Nasarawa Niger Abuja Average On station LS

AFE 150 ±2.23 146 ±2.80 151 ± 3.00 156 ±3.03 143±2.52 149 ±2.71 141 ±2.23 Ns

Clutch No. 3.31 ±0.03 3.06 ±0.43 3.03 ±0.11 3.23 ±0.23 3.00 ±0.53 3.13 ±0.26 3.22 ±0.13 Ns

Clutch size 11.20±0.12b  11.24±0.11b  11.45±0.23b  10.95±0.15b 10.84±0.23b 11.14± 0.17 13.11±0.23a \*\*\*

Egg Inc. 8.71±0.01c 11.17±0.21 b 11.38±0.32 b 10.70±0.06 b 10.32±0.15 b 10.48± 0.1114.11±0.23 a \*\*\*

Egg Ha 8.48±0.42 c 10.93±0.63 b  11.28±0.44 b 10.43±0.03 b 10.14±0.06 b 10.25± 0.02 13.11±0.16 \*\*\*

Ch. Wn 3.91±0.63 c 5.29±0.72 b 5.21±0.07 b  5.20±0.41 b 5.76±0.06 b 5.04±0.06 9.60±0.44 a \*\*\*

Hatch.ty 97.36±0.33 97.85±0.4199.12±0.2697.48±0.4398.26±0.32 98.01± 0.35 94.81±0.45 Ns

Mortality 4.57± 0.32 b 5.64± 0.02 b 6.07± 0.04 b  5.23± 0.35 b 4.38± 0.32 b 5.18± 0.32 3.51±0.01 a \*\*

(53.89) (51.60) (53.81) (50.14) (43.19) (41.89) (26.78)

Note: \*\* = (P< 0.01). \*\*\* = (P< 0.001). Means in row with different superscripts are significantly different.

Inc = incubated, Ha = hatch, Ch.wn = chick weaned, Hatch.ty = hatchability, No. = Number, AFE = age at first egg.

Figures in parenthesis are percentages.

Table 22: Pearson correlation between body measurements

BodyLength Body width ShankLength WingLength BeakLength CombLength BreastHeigth BreastLength Body weight

BL 0.233\*\* 0.90\*\* 0.266\*\* 0.260\*\* 0.558\*\* 0.225\*\* 0.273\*\* 0.104\*\*

BWI 0.19\* 0.121\*\* 0.117\*\* 0.239\*\* 0.085\*\* 0.231\*\* 0.104\*\*

SHL 0.027\* 0.007 0.119\*\* 0.038\*\* 0.057\*\* 0.038\*\*

WL 0.112\*\* 0.387\*\* 0.139\*\* 0.154\*\* 0.050\*\*

BKL 0.389\* 0.127\*\* 0.152\*\* 0.052\*\*

CL 0.251\*\* 0.282\*\* 0.123\*\*

BRH 0.108\*\* 0.062\*\*

BRL 0.057\*\*

BW

\* Correlation is significant at the 0.05 level

\*\* Correlation is significant at the 0.01 level

Table 23: Correlation among egg parameters.

Egg weight Egg Length Egg Width Shell Thickness Shell Weight Albumen Wt Albumen ht Yolk Width

EW 0.036\*\* 0.073\*\* -0.024ns 0.036\* -0.014ns 0.048\*\* 0.041\*\*

EL 0.180\*\* 0.004ns 0.006ns 0.018\*\* 0.018\*\* 0.018\*\*

EWi -0.014ns 0.070\*\* -0.053\*\* 0.108\*\* 0.096\*\*

STH 0.054\*\* 0.008ns 0.013ns -0.012ns

SW 0.017\*\* 0.047\*\* 0.009ns

A.W 0.036\*\* 0.122\*\*

A.H 0.389\*\*

Ywi

\* = Significant at \*P<0.05

\*\* = Significant at \*\*P<0.01

**Table 24:** Correlation among performance traits in the study area

Mature Hen weight clutch size No. EI No,CH No. EW No. CW Hatchability Av.E Wt Av.E L Av.EWi Av.mortality

MWt 0.146\*\* 0.071ns 0.024ns -0.066 0.014ns 0.168\*\* 0.162\*\* 0.123\*\* 0.162\*\* 0.048

CS 0.174\*\* 0.104ns -0.006ns 0.018ns -0.018 -0.031 -0.089 -0.054 -0.014ns

EI -0.014ns 0.170\*\* -0.053 - 0.008 - 0.096 0.008ns -0.012 0.097\*

CH 0.054\* 0.008ns 0.013ns -0.012ns 0.017ns 0.057\* 0.009ns

EW 0.017ns 0.047 0.009ns 0.017ns 0.047 0.009ns

CW -0.036 0.122\*\* 0.017ns 0.047 0.009ns

HB 0.189\*\* 0.033ns 0.054ns 0.032ns

EWT 0.012ns 0.043ns 0.034ns

EL 0.064ns 0.087ns

MTY 0.033ns

\* = Significant at P< 0.05 \*\* = Significant at P<0.01 .Wt=weight, El, =eggs incubated, CH= chick hatched, EW= egg wasted, CW, = chick weaned Hb= hatchability, Ewt= egg weight, EL=egg length, Ewi=egg width.

**4.15 Relationships between observable characteristics and measurements**

Means of body measurements and egg characteristics in local chickens affected by plumage are presented in Tables (25 - 27). Out-station mean body weight, width, shank, comb, breast lengths and height were significantly (P<0.01) affected by plumage. Beak and wing lengths were also affected (P<0.001). Birds with black/ brown plumages differed and were heavier (2.011±0.040kg) than other colours of black, white, black/white, brown, yellow and mottled. Body measurements (body weight, width, shank, beak, comb, wing, breast lengths and height) and body weight were affected significantly (P<0.01) by plumage and sex of bird (Table 26).

Most egg measurements (egg length, egg width, albumen height and width, yolk width and haugh unit) were affected (P<0.01) by plumage except shell thickness, egg weight and shell weight (Table 27). Birds with black/white plumages had better haugh unit and albumen characteristics.White plumage birds also showed considerable performance in albumen characteristics, while black and mottled plumages differed from other plumages in yolk characteristics.

Table 25: Out- Station means of body measurements of local chickens affected by plumage

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mean Standard Error | | | | | | | | | |
| Parameter | Black | White | Black/White | Brown | Black/Brown | Yellow | Mottled | Overall | LS |
| Body weight(kg) | 1.870.04b | 1.940.04b | 1.950.03b | 1.930.03b | 2.010.04a | 1.960.04b | 1.940.14b | 1.950.03 | \*\* |
| Body length(cm) | 19.780.22 | 19.440.23 | 19.380.21 | 19.830.21 | 19.390.22 | 19.790.25 | 19.350.21 | 19.570.08 | NS |
| body width (cm) | 18.450.23b | 17.580.24c | 18.250.22b | 18.450.22b | 18.330.22b | 18.610.26a | 18.550.22b | 18.320.08 | \*\* |
| Shanklength(cm) | 9.79±0.41b | 8.74±0.42b | 8.68±0.39b | 9.59±0.38b | 9.59±0.39b | 10.01±0.46a | 8.92±0.39b | 9.33±0.14 | \*\* |
| beak length(cm) | 3.03±0.05b | 2.93±0.05c | 3.13± 0.05b | 3.05±0.05b | 3.27±0.05a | 3.18±0.06b | 3.16±0.05b | 3.11±0.02 | \*\*\* |
| comb length(cm) | 2.65±0.04b | 2.51±0.41 | 2.51±0.03c | 2.71±0.03a | 2.51±0.03c | 2.75±0.04a | 2.71±0.03a | 2.65±0.01 | \*\* |
| wing length(cm) | 14.07±0.32b | 14.01±0.33b | 14.35±0.30b | 14.41±0.30 | 14.34±0.31b | 15.74±0.35a | 14.17±0.30b | 14.44±0.11 | \*\*\* |
| breast length(cm) | 18.37±0.19a | 17.77±0.19b | 17.77±0.18b | 17.95±0.18c | 18.24±0.18a | 18.22±0.21a | 18.23±0.18a | 18.084±0.06 | \*\* |
| breast height(cm) | 11.72±0.14a | 11.60±0.14a | 11.67±0.13a | 11.72±0.13a | 11.77±0.13a | 11.71±0.16a | 11.36±0.13b | 11.65±0.55 a | \*\* |

LS = Levels of Significant. NS = Not Significant (\*\* = P<0.01, \*\*\* = P<0.001). Means in row with different superscripts are significantly different

Table 26: Overall means of body measurements affected by plumage and sex

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mean ± Standard Error | | | | | | | | | | |
| Parameter | Sex | Black | White | Black/White | Brown | Black/Brown | Yellow | Mottled | Overall | LS |
| Body weight(kg) | M. | 2.14±0.05a | 2.22±0.06a | 2.22±0.05a | 2.25±0.05a | 2.32±0.04a | 2.28±0.05a | 2.27±0.06a | 2.25±0.03 | \*\* |
| F. | 1.59±0.07b | 1.65±0.05b | 1.61±0.05b | 1.60±0.06b | 1.69±0.05b | 1.64±0.08b | 1.62±0.05 | 1.63±0.03 |
| Body length (cm) | M. | 20.49±0.31a | 20.62±0.34a | 20.23±0.33a | 20.71±0.032a | 20.62±0.33a | 20.01±0.30a | 20.16±0.33a | 20.55±0.16 | \*\* |
| F. | 19.08±0.39b | 18.26±0.30b | 18.54±0.30b | 18.96±0.33b | 18.15±0.30b | 18.57±0.45b | 18.54±0.30b | 18.59±0.16 |
| Body width(cm) | M. | 18.88±0.32a | 17.97±0.35a | 18.41±0.34a | 18.77±0.33a | 18.69±0.34a | 18.77±0.31a | 18.76±0.34a | 18.61±0.17 | \*\* |
| F. | 19.08±0.40b | 17.20±0.31b | 18.09±0.31b | 18.13±0.34b | 17.97±0.31b | 18.45±0.47b | 18.34±0.31b | 18.04±0.17 |
| Shank length (cm) | M. | 9.25±0.56a | 8.38±0.61a | 8.38±0.59a | 8.93±0.58a | 9.47±0.60a | 9.64±0.58a | 8.52±0.60a | 8.94±0.29 | \*\* |
| F. | 10.33±0.71b | 9.09±0.54b | 8.99±0.55b | 10.25±0.60b | 9.71±0.54b | 10.37±0.82b | 9.32±0.55b | 9.72±0.29 |
| Beak length(cm) | M. | 3.32±0.07a | 3.22±0.08a | 3.36±0.08a | 3.19±0.07a | 3.49±0.08a | 3.46±0.07a | 3.49±0.08a | 3.36±0.04 | \*\* |
| F. | 2.75±0.07b | 2.65±0.07b | 2.89±0.07b | 2.90±0.08b | 3.06±0.07b | 2.90±0.11b | 2.82±0.07b | 2.85±0.04 |
| Comb length (cm) | M. | 3.10±0.05a | 3.11±0.06a | 2.90±0.05a | 3.16±0.05a | 3.08±0.05a | 3.28±0.05a | 3.27±0.05a | 3.13±0.02 | \*\* |
| F. | 2.20±0.07b | 2.25±0.05b | 2.12±0.05b | 2.25±0.05b | 1.94±0.05b | 2.27±0.08b | 2.16±0.05b | 2.16±0.02 |
| Breast length(cm) | M | 18.58±0.26 a | 18.13±0.28a | 18.13±0.27a | 18.23±0.27 a | 18.35±0.28 a | 18.48±0.26a | 18.65±0.28a | 18.39±0.13 | \*\* |
| F | 18.16±0.33 b | 17.23±0.25b | 17.40±0.25b | 17.66±0.28 b | 18.13±0.25 | 17.97±0.38b | 17.81±0.25b | 18.39±0.13 |
| Breast height(cm) | M | 12.45±0.19 a | 12.25±0.21 a | 12.24±0.20a | 12.49±0.20 a | 12.61±0.21 | 12.50±0.31a | 11.66±0.21a | 12.31±0.10 | \*\* |
| F | 11.01±0.24 b | 10.95±0.19b | 11.09±0.19b | 10.96±0.21 b | 10.94±0.19 b | 10.92±0.28b | 11.06±0.19b | 10.99±0.10 |

LS = Levels of Significant. NS = Not Significant (\*\* = P<0.01). Means in column with different superscripts are significantly different.

Table 27: Out-Station Means of egg measurements affected by plumage

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mean ± Standard Error | | | | | | | | | |
| Parameter | Black | White | Black/White | Brown | Black/Brown | Yellow | Mottled | Overall | LS |
| Egg weight(g) | 39.31±0.80 | 40.05±0.86 | 38.25±1.14 | 39.68±0.95 | 39.28±0.82 | 40.08±1.03 | 38.06±0.82 | 39.27±0.82 | NS |
| Egg length(cm) | 3.77±0.07b | 3.68±0.08b | 3.75±0.18 | 3.84±0.16 | 3.66±0.16 | 3.65±0.21 | 4.00±0.16 | 3.63±0.15 | \*\* |
| Egg width(cm) | 3.83±0.07b | 4.00±0.07a | 3.94±0.10 b | 3.96±0.08 b | 3.80±0.09b | 3.71±0.11c | 3.74±0.09c | 3.87±0.06 | \*\* |
| Eggshell weight(g) | 4.07±0.13 | 4.27±0.14 | 4.49±0.19 | 4.07±0.16 | 4.33±0.15 | 3.97± 0.19 | 4.47±0.15 | 4.08±0.09 | NS |
| Eggshell thickness(mm) | 1.03±1.12 | 1.93±1.20 | 0.81±1.60 | 2.35±1.33 | 0.42±1.00 | 0.72± 1.25 | 0.46±0.99 | 0.53±0.01 | NS |
| Albumen height(cm) | 4.48±0.10b | 4.57±0.10b | 4.81±0.10a | 4.67±0.08 b | 4.47±0.12 b | 4.33±0.16c | 4.55±0.1 b | 4.48±0.06 | \*\* |
| Albumen width(cm) | 18.87±0.1d | 19.11±0.28 a | 19.01±0.10a | 18.58±0.23b | 18.75±0.20d | 18.46±0.26b | 19.05±0.12 | 18.89±0.17 | \*\* |
| Yolk width(cm) | 13.32±0.20a | 13.28±0.21b | 12.60±0.28c | 12.57±0.24c | 12.07±0.24c | 12.41±0.30c | 13.35±0.23b | 13.09±0.16 | \*\* |
| Haugh unit | 92.02±0.56 b | 92.33±0.61b | 93.80±0.80a | 92.88±0.66b | 91.89±0.70c | 90.90±0.88 | 92.50±0.70b | 92.44±0.47 | \*\* |

**Note: -** Ns = Not Significant, (\*\*P<0.01). Means in row with different superscripts are significantly different.

**CHAPTER FIVE:**

**5.0 DISCUSSION**

**5.1 Socio–economic Characterization of Indigenous Chicken Farmers**

The high percentage of rural women involved in rearing indigenous chickens is an indication that it is an appropriate activity for them (Smith, 1990). This might have arisen because women have little or no access to land due to the ownership system which is gender biased (Alemu, 1995). The keeping of chickens requires low amount of land. It can easily be embarked on in addition to other activities; women therefore find it very appropriate (Smith, 1990, Bradley, 1992; Alemu, 1995; Tadelle and Ogle, 1996; Gueye 1998). Since it can be engaged upon along other activities, it is considered a sideline agricultural activity. This is also in agreement with the reports of Gueye (1998) and Mcainsh *et al.* (2004) that 80 % of chicken flocks in a number of African countries were owned and largely controlled by women while embarking on other activities. Chickens were mostly kept by elderly and married individuals. This might have arisen again because of the ease associated with the enterprise and availability of time (Gueye, 1998) Sometimes children also owned birds which may be useful for personal needs such as purchase of clothes and school expenses.

Most chicken farmers were informally educated; this could have hampered effective and sustainable genetic improvement programme in rural areas and might have been the reason why rural poultry improvement programme of the late 1960s and early 1970s did not achieve sustainable progress. However inadequate extension, institutional and organization supports might also have led to the inability of indigenous chicken farmers to maintain high management standard (Kaiser, 1990, Adegbola, 1998). The indigenous chicken sector constitutes a major contribution to livelihood and food security.

There should be a focus on the education and training of women since they play dominant role in the village poultry production. Improving education of women will also affect the overall socio-economic status of the family and the society (Bradley, 1992; Alemu, 1995).

**5.2 Major Crop Activities by Farmers**

The high percentage of farmers that cultivated various crops that favoured poultry production; cereals (maize and rice), root and tubers (cassava and yam) indicate that the indigenous chickens are able to meet most of their nutrient requirements by scavenging on household and kitchen wastes and part of poorly harvested crops from the farm. This observation agrees with what was reported by Kuit *et al.* (1986), Aichi (1995) and Yongolo (1996) that the indigenous chickens are basically left to scavenge on farm residue and household refuse and grains and their production varies with the farming systems adopted.

**5.3 Management of Indigenous Chickens**.

That majority of the chicken population in the study was raised extensively without provision of separate housing indicated that they were predisposed to predation, disease and harsh weather condition that affected performance. Similar observation had been reported by Aichi (1995), Okoh *et al*. (2009), Selam and Kelay (2013). A high percentage of farmers ear marked areas for chickens to rest at night with little or no permanent structure, which agrees with the work of Hurchzermeyer (1973), Kuit *et al.* (1986), Sonaiya (1990) and Yongolo (1996); they reported that most indigenous chickens were not provided with permanent shelter but a few areas marked for rest at night within the family compound, kitchen or corners of the house, while others perch on trees. Chicken housing was observed to be greatly influenced by farming system; farmers/families that were settled provided more permanent structures than migratory ones. Thus crop farmers provided better housing than those that were always on the move. This observation has also been reported by Kuit *et al.* (1985).

Poor sanitary practices such as more than a month cleaning of pens and infrequent watering which were both high might have been the reason for the frequent predisposition of indigenous chickens to common poultry diseases such as Newcastle disease and Coccidiosis. This had also been reported by Otchere *et al*. (1989). Poor housing and the extensive system which allow for free movement of large populations of indigenous chickens, ducks and free flying birds together continue to maintain virulent disease viruses in circulation (Newathe and Lamorde,1987). Newcastle disease ranked among the most important disease of poultry in Africa (Aichi, 1995).

Feeding regime was also poor; birds were occasional supplemented household refuse and grains. In view of the generally little consideration to conscious feeding of indigenous chickens, Nwosu (1979) described them as the “neglected child”.

Research in other parts of Africa such as Tanzania (Yongolo, 1996), Burkina Faso (Bourzat and Saunders, 1990), Mauritania (Bell *et al.,* 1990), Benin (Chrysostome *et al.,* 1995) also reported Newcastle as the most devastating disease of indigenous chickens. The high prevalence of this disease is caused by the lack of routine vaccination.

**5.4 Flock Structure**

Flock structure gives the proportion of the different age groups and sexes (Van Veluw, 1987). Flock size varies mainly due to the availability of feeds, the occurrence of diseases, the presence of predators as well as the economic status of the owners (Buldgen *et al.,* 1992). There is also a close association between flock size and the prevailing farming system. Flock structure has been used to study flock dynamics (Vanvelew, 1987; Wilson *et al,* 1987; Abdou and Bell, 1992; Buldgen *et al*., 1992). The proportion of mature hens is used to estimate egg and chicken productivity. Egg production and chick survival are the key parameters used to study village chicken flock characteristics (Aichi. 1995). The variation in sex percentage in favour of cock may have arisen due to the preference attached to keeping males for economic (sale) rather than breeding purposes (Mbap and Zakar, 2000). This observation does not agree with reports from other parts of Africa where sex percentage favoured hens. In Ethiopia the proportion was 3.49 hens 1.31 cocks, 3.18 growers, 3.92 chicks and 2.87 chicks while Gambia had 2.22 hens, 0.68 cocks, 3.18 (Aichi, 1995). Meat and tradition had been found to be the most frequent motivation for farmers in keeping indigenous chickens (Oluyemi and Roberts, 1979).

**5.5 Single Major Gene Traits of Indigenous Chicken Population**

Information on single major gene traits shows that naked neck and frizzle feather were prevalent in the population. The naked-neck fowls have been reported to have greater flexibility in temperature regulation according to Fraga *et al.* (1989), hence, the obvious prevalence in the study area where temperature is usually high all year round. This is also in agreement with several researches (Merat *et al.,* 1974; Merat and Bordas 1974; Bordas *et al*., 1978; Merat, 1979; Monnet *et al.,* 1979; Zein El Dein, 1981; 1984; Bordas and Merat, 1984; Rauen, 1985) that reported that low feathering intensity due to the naked neck genes enable the chickens which do not have sweat gland to improve thermoregulatory efficiency especially under heat stress by increased insensible heat loss via the uncovered body surfaces. Hence, productivity under hot environmental conditions in the study area could be improved through the introduction of the naked neck gene (Horst, 1988).

**5.6 Comb Type Distribution of Indigenous Chicken**

The single comb was most prevalent. The prevalence of single comb type in this study had also been reported by Ikeobi *et al.*  (2001) and Mancha (2004). The high frequency of the single comb type (through genotypically, rrpp) even in a population of Rr+ individual is because the RR genotype has poor fertility in several breeds (Crawford, 1990). In addition single comb alleles are epistatic in nature (Hut, 1949), hence contributing to preponderance of the single comb type. Combs are important avenue for heat loss in birds (Horst, 1989). The walnut and rose comb types were least common because they tend to reduce heat lose, such that birds with these comb types were predisposed to higher heat load, metabolic rate and thyroid activity which led to decreased productivity and increased mortality (Horst,1988). The high incidence of single comb is an advantage in the studied population found in an environment which is hot almost through out the year. The comb, thus serves thermoregulatory function to ensure survival and productivity (Van-Kampen 1974; Oluyemi and Roberts, 1979; Obioha, 1992; Ssewanyana *et al.,* 2001).

**5.7 Colour Variation**

The varied plumage colouration in indigenous chickens makes it difficult to describe them in terms of plumage colour that can reproduce true to type. That there was multiplicity of plumage colours and certain colours such as red were restricted to particular body parts especially the neck with varying amount of shiny black, have been reported (Hill. 1954, Obioba, 1992). Brown chickens were common. This agrees with Saidu (2002) and Mancha (2004). This is also in agreement with previous studies in Senegal (Missohou *et al*., 1998) and other countries (Mcainsh *et al*., 2004; Bhuyian *et al*., 2005; Badubi *et al*., 2006). Black/white and black were other dominant colours in the study. Dominant plumage colours reported for indigenous chickens were brown, black, red, ash and grey-ash (Eshette and Okere, 1982). Black mottled with brown and white has also been reported (Adebambo *et* *al*., 1999). Duguma (2006) further found similar results in Horro, Tepi and Jarso indigenous chickens of Ethiopia

Social preference, geographical location, unconscious selection in addition to natural selection and adaptation could be the major causes of the variation in plumage colour between populations (Ikeobi *et al*., 2001). However, within populations interbreeding and lack of selection have been reported as the main source of variation in colour (Nwosu, *et al.,* 1985; Okoh *et al.,* 2009).

Plumage colour in birds had been reported to be controlled by the E- locus which enhances the distribution of melanin (Mukherjee, 1990). Accumulation of eumelanin intensifier is probably responsible for solid black colour variant (Moore and Smith 1971).

A number of genes act as eumelanin inhibitor and modify plumage colours (Cote, 1976). Mixed (mottled) colour and patterns result from interaction between genes at different loci in addition to the activities of unidentified modifying genes that behave like polygene, furthermore tissue specific mutation can bring about variations in plumage (Cote, 1976).

Some polygenes may not have been discovered because their effects might have been suppressed or altered by the gene interaction or epistasis. They needed to be uncovered for application in colour improvement (Okoh *et al.,* 2009).

While the three shank colours – black, white and yellow might have been due to genetic interaction (Cole, 1976), colour variation may also be due to feed resources or supplements that result in pigmentation (Okoh *et al*. 2009). Cole(1976) specifically found that black shank colour was due to presence of melanin pigment in the epidermis, while white was as a result of absence of both absence of both lip – chrome and melanin pigment.

Black beak colour was greater in proportion than other colours. This observation is in agreement with the work of Nwosu and Omeje (1983), Adebambo *et al*. (1999) and Ikeobi *et al. (*2001) who observed that beak pigmentation may be due to natural selection, adaption and nutrition.

White skinned chickens were most common in this study. This observation is in agreement with the work of Ssewannyana *et al*. (2001), Saidu (2002) and Mancha (2004) who reported white skin as dominant colour. Crawford (1984) reported that skin pigmentation is due to absence or presence of melanin. The combs and ear lobes that were mostly red in the chickens had also been reported (Oluyemi and Roberts 1979; Bogale, 2008). Ear lobe colour reported in this study differs from those reported by Ssewannyana *et al*. (2001) in favour of white or red and Mancha’s (2004) brown. The common yellow eye colour observed in the indigenous chicken differs from the dorminant red or pinkish reported by Mancha (2004). The presence of carotenoid pigment found in several sites in the Iris and the photoreceptor cone cells that contain oil droplets that have carotenoid pigment dissolved in the eyelid might be responsible for the yellow eye colour (Duncan, 1955). The common brown colour of egg in the study area might have influenced the better internal quality of egg. This observation has been reported earlier by Curtis *et al.* (1985) that shell colour affect interior quality; with brown showing better quality than white. Buss (1982) also reported brown as dominant colour. Egg colour is a visual appraisal and consumer’s preference for brown egg shell might have been the reason for the predominance of brown colour. This observation has been reported by North (1976) that egg colour attract consumer’s attention and colour preference varies with society.

**5.8 Body Measurements**

The out-stationl adult average body weight for indigenous chickens in this study was higher than those reported by Mancha (2004) but lower than 3.0kg reported by Mbap and Zakar (2000). Furthermore males had higher body weight than females. Mature body weight had been reported to within the ranges of 0.680-1.588kg for hens and 0.907 - 2.041kg for cocks (Hill, 1954) of the light and 1.5-2.5kg for those of the heavy ecotypes (Atteh, 1990). Hence, chickens in the study area could best be described as middleweight ecotypes. The mean body length in this study is slightly higher than the value of 17.80±1.51cm reported by Nwosu and Okoye (1978) and so is 7.54±0.04cm for shank length. The mean overall wing length in this study was lower than 17.4cm reported Ukwu *et al.* (2014). The mean overall beak length reported in this study was higher than 2.48 and 2.29 cm reported by Vincent *et al.* (2015). Breast height and length showed that males were meatier than female and for all other characteristics; this is expected because male chickens are usually bigger and exhibit overall masculine frame (Obioha, 1992; Okpekwu, 2003; Fayeye, 2005). The general similarities in linear body measurements of the indigenous chickens may be an indication that they belong to the same stock and variability could be due management and season of observation (Ozoje and Ngere, 2007).

**5.9 Egg Characteristics and Productivity of Indigenous** **Chickens**

The mean egg weight obtained in this study is higher than the 28gand 29.37g mentioned by Williamson and Payne (1978) and Mbap and Zakar (2000) but similar to 36 – 41g (Sonaiya *et al.,* 1998; Sonaiya, 2003) for indigenous chickens in Nigeria. Oluyemi and Roberts (1979) reported 30g for tropical environments, but 38- 40g in other parts of Africa (Ethiopia and Malawi) have been observed by Brannang and Pearson (1990), Tadelle and Ogle (2001) and Safalaoh (2001). For improved breeds Obioha (1992) and Narushin and Romanov (2007) gave 50- 60g as standard weights. Higher values of 46, 58 and 60g for indigenous birds, White Leghorn and exotic breeds had been reported (Teketel, 1986; Brannang and Pearson, 1990 and DZARC, 2007).The lower egg weight in this study compared to most studies cited might have been due to environment, breed or strain effects (Sonaiya *et al.,* 1998). Mean egg length in the present study is lower than 5.77 – 6.12cm reported by Mbap and Zakar (2000). The non-significant difference in egg length, shell weight, albumen weight and yolk width between states is a reflection of the similarity of the indigenous chickens in the study area. The egg weight, length and width values of indigenous chickens also showed that they were smaller compared with exotic breed. The egg quality rating (Haugh unit) of 84.36 – 91.16 reported by Awosanya *et al.* (1998) is lower than the value obtained in this study. The egg shell thickness obtained in this studyis higher than 0.34 – 0.35mm and 0.36±0.01 reported by Awosanya *et al.* (1998) and Mancha (2004) respectively. Mebratu (1997) and Chineke (2001) also gave lower values of 0.31 – 0.38mm and 0.31±2.37mm respectively for egg thickness. The importance of good shell thickness is that it enables the best use of nutrients contained in the egg by the embryo (Sergeyeva, 1976). There is lesser chances of bacteria penetration (Fisinin *et al.,* 1990), dehydration (Roque and Soares, 1994) and also offers the best protection from mechanical damage (Sergeyeva, 1976; Tsarenko, 1988).

Mean age at first egg in this study is lower than 157 ± 3.21days reported by Omeje and Nwosu (1984), 169.5 ± 2.8days, Akinokun, (1990) and 150 – 169 days (Sonaiya, 1990). Work from three agro-ecological zones of derived, guinea savannah and, rainforest of Nigeria by Adedokun and Sonaiya (2001) reported values of 157 ± 3.7, 160 ± 3.8 and 165 ± 3.7 days. Mogesse (2007) reported age at first egg production of indigenous chicken ecotype of Ethiopia as 144 days. Ali *et al.* (2003) also had 144.3 days for indigenous chicken ecotypes of Tanzania. There were fairly good clutch size and hatchability in the present study. Omeje and Nwosu (1984) reported 16 ± 1.0 clutches/year. Under extensive system, chicken lay up to three clutches of 12 – 18 eggs per year (Williamson and Payne, 1978). Otchere *et al.* (1990) reported average clutch size of 10.4 for Nigerian indigenous chicken under scavenging system. Hatchability in this study is higher than 62% reported by Msoffe *et al. (*2007). Values of 75% (Barua and Yoshimura, 1997) 90%, Wilson (1979) and, 88.70±1.48, 82.55±1.23, 84.25±1.04 and 83.87±1.26% for frizzle, dwarf, naked neck and normal feathered chickens have also been reported (Okoh *et al*., 2010). The good hatchability recorded might be due to moderate egg weight and shell qualities since hatchability is influenced by them (Tsarenko, 1988). Deeming (1996) stated that high egg weight, hatchability is reduced but it increased with moderate values which in turn affect post hatch mortality. The high percentage hatchability recorded in this study is an indication of good reproductive performance.

**5.10 Correlation of Traits between Body Measurements**

The positive correlations between body measurements showed that the traits could be used to predict each other. Selection for a particular body measurement could lead to responses in others. Correlated responses could also be used to hasten selection processes to develop the indigenous chickens.

**5.11 Correlations Between Egg Characteristics and Productivity**

The positive correlation of mature hen weight with egg production characteristics is an indication of possible genetic responses in the former by selection for the latter. Improvement could be feasible by selecting for characteristics which can be assessed easily.

**5.12 Relationship Between Observable Characteristics and Measurements**

The relationship between observable characteristics and other measureable attributes which are significant for some traits showed that selection can be used to improve other measurements. This observation has been reported earlier (Mancha, 2004). The significant difference between black/ brown plumage from other colours with the highest body weight in the population is an indication that the former can be used as criteria to select for higher body weights in local chickens in the study area. This is also true for some egg characteristics. However, plumage colour did not affect the ability of chickens to lay bigger eggs since egg weight was not affected by plumage in the study area.

**CHAPTER SIX**

**6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS**

**6.1 Summary**

A total of 6176 adult indigenous chickens of mixed sex were assessed from four states of the North Central zone namely; Nasarawa, Niger, Benue, Kogi and the Federal Capital Territory in order to characterize the indigenous chickens for physical and productive attributes. Data were collected as Out-station and On-station on live weight, linear measurements, productivity and egg characteristics (external and internal). The out station data were generated via participatory rapid appraisal technique.

A total of 73% of farmers that kept indigenous chickens were female, 64.9% had no formal education. Those that kept solely indigenous chickens were 51.48%. Over 50% of chicken owners were above 50 years of age and married (86%). Percent crop cultivation revealed high values for maize 42.68% and cassava (41.68%). Over half of the respondents (57.8%) kept chicken extensively. Sanitation was poor, 66.5% did not clean pens regularly and 73.2% of birds were on scavenged feeds. Many farmers (68.44%) did not supply water frequently. Newcastle disease was the most prevalent (63.22%) disease. Flock structure favoured cock (28%) and single comb was 85.90%. Majority of birds, 89.78% had normal feathering followed by naked neck, 7.58%.

Brown plumage was highest, 19.81%. Beak and shank colours were mostly black 60.01 and 62.5% respectively. White skin chicken was most numerous, 74.4%. Comb, eye and ear lobe were similar and were mostly red with similar percentages 86.03%. Egg shell colours were brown 58.99%. The Out-Station mean mature body weight was 1.88±0.01kg and it varied significantly (P<0.01) by state and by sex. The mean out-station body length, body width , shank, wing, beak, comb lengths, breast height, breast length were 19.36± 0.02, 18.25 ± 0.01, 9.39± 0.03, 14.23± 0.03, 3.12±0.01, 2.64±0.01, 11.60± 0.33 and 11.60± 0.33cm respectively. All body measurements differed significantly (P<0.001) by sex. However, shank, beak, comb lengths and breast height did not differ significantly by state.

Body length was positively correlated with body width, shank, wing length, beak length, comb length, breast height, breast length, and body weight.

Out- station egg weight, length, width, shell thickness, shell weight, albumen width, albumen height, haugh unit and yolk width values were 39.59 ±0.06g, 3.80±0.01cm, 3.89 ± 0.01cm, 0.54± 0.06mm, 4.18± 0.01g, 18.78±0.02cm, 4.57±0.03cm, 76.31±0.16 and 12.76±0.02cm, respectively. Egg weight was positively correlated with egg length, egg width, albumen height and yolk width.

Clutch size ranged from 10.84± 0.23 to 13.11 ± 0.23 in Abuja and on-station respectively. Number of eggs incubated ranged from 8.71±0.01to 11.38±0.32in Benue and Nasarawa state. Nasarawa had the highest (99.12%) hatchability, while Benue had the least (97.36%). Mortality to weaning ranged from 43.19 to 53.89% in Abuja and Benue respectively. There was a significant difference in mortality by site. Significant correlations were observed between mature hen weight and clutch size, mature hen weight was positive and significantly correlated with hatchability, egg weight, length and width.

Body weight was affected (P<0.01) by plumage. Black/ brown colours were mostly affected. Body width and shank length were significantly affected (P<0.01) by plumage but did not differ across states. Similarly, other observable characteristics of beak, comb and wing lengths were significant (P<0.01).

* 1. **Conclusion**

Conclusively, the indigenous chicken in the guinea savannah zone can best be described as middle weight ecotype (0.88±0.01kg). Women were more involved in chicken production therefore increasing their income, if educated their productivity would increase. The variations observed in body measurements and qualitative traits support the polyphyletic theory that the ancestors are combinations of different species. The generally high percentage of males in the flock indicated that productivity was more commercial than general breeding. Poor housing, nutrition, sanitation, diseases and feeding are the major challenges to chicken production in the study area. The higher percentage of single comb is an indication that most chickens possessed heat tolerance mechanism. The high proportion of naked neck gene indicates that productivity under hot environmental condition could be improved through the introduction of the gene, since they are effective in temperature regulation. The many similarities in body measurements would suggest that the birds belonged to the same stock. The high egg qualities and hatchability are indication of good reproductive performance in the chickens. The significant differences in black/brown plumage chickens for body weight can be used to select for higher body weights in indigenous chickens. The positive correlations between body measurements showed that the traits could be used to predict each other and thus aid selection. Selection for a particular body measurement could lead to positive responses in others and such correlated responses could be used to hasten selection processes to develop the indigenous chickens.

* 1. **Recommendations**

Based on the findings of the study, the following recommendations are made:

1. Proper housing and feed supplementation for indigenous chickens should be seriously considered.
2. Sanitation and health care should be strictly adhered to, in order to prevent most of the common diseases.
3. Efforts should be made to vaccinate indigenous chicken against common fowl diseases such as Newcastle diseases and Coccidiosis, which are highly endemic in the study area.
4. To adequately meet the shortfall of protein requirement and income of rural dwellers; there should be deliberate and sustainable improvement programmes for indigenous chickens for meat and egg especially using correlated traits.

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**Appendix 1: FIELD QUESTIONNAIRE**

*CHARACTERIZATION OF INDIGENOUS CHICKENS OF THE NORTH CENTRAL AGRO-ECOLOGICAL ZONE OF NIGERIA*

**QUESTIONNAIRE:**

**A. GENERAL INFORMATION/PERSONAL DATA:**

1 State/Indigenous Government Area:………………………………………

2 Village:……………………………………………………………………..

3 Name of Respondent/Householder:……………………….......................

4 Sex:………………………………………………………………………..

5 Education Qualification:………………………………………………….

6 Occupation:……………………………………………………………….

7 If Farming, Main Crops Cultivated:………………………………..……

8 Do you keep chickens? Yes ( ) No ( )

If yeas……………………………………………………………………..

…………………………………………………………………………….

9 No of Exotic (Agric) Chickens:……………………………………….….

10 No of Indigenous Chickens: (i) Hens ( ) (ii) Cocks ( )

(iii) Growers ( ) (iv) Chicks ( )

**B. PRODUCTION SYSTEM**

1 Housing:

Where do the chickens rest at night?

(a) Do not know ( )

(b) Kitchen/store ( )

(c) In the main house ( )

(d) Perch on trees ( )

(e) Constructed chicken house ( )

(f) Others (specify) ( )

2 Do you clean the chicken house? Yes ( ) No. ( )

If yes, how often do you clean the chicken house?

(a) Daily ( ) (b) Weekly ( ) (c) Monthly ( )

(d) Less than once per month ( )

3 Feeding

Do you give supplementary feeding (other than scavenged feed?)

Yes ( ) No. ( )

If yes, please fill the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of supplement** | **Source/Household, harvest, purchase** | **If purchased unit price** | **Quantity and time of feed per day** |
|  |  |  |  |
|  |  |  |  |

Do you provide water for the chickens Yes ( ) No. ( )

If yes fill the table below

|  |  |  |
| --- | --- | --- |
| **Sources of water (well, river, bore hole)** | **Type of drinker** | **How frequency do you provide the water** |
|  |  |  |

4 Health Care

Do you have access to veterinary services? Yes ( ) No. ( )

If yes, how often do the veterinary personnel visit?

(a) Weekly ( ) (b) Monthly ( ) (c) Once in a while ( )

Do you vaccinate your chickens? Yes ( ) No. ( )

If yes, against what disease(s)

(i)……………………………………………..

(ii)…………………………………………….

(iii)……………………………………………

Have you experienced any disease problem in your flock this month?

(Monthly information) Yes ( ) No. ( )

If yes indicate below the symptom/disease and control measures taken.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Types of disease/symptom** | **Control measure** | **Last occurrence in flock** | **Age group affected** | **Frequency of occurrence often, not often** |
| Swollen head |  |  |  |  |
| Swollen joints |  |  |  |  |
| Coughing |  |  |  |  |
| Diarrhea |  |  |  |  |
| Twisted neck with paralyzed leg and wings |  |  |  |  |
| Fowl pox/watts |  |  |  |  |
| Fleas, mites |  |  |  |  |
| Ticks |  |  |  |  |

What is the commonest disease/symptom observed?

(a) Rainy (wet) Season ( ) (b) Dry season ( )

**C. Flock Characteristic:**

|  |  |
| --- | --- |
| **Predominant** | **No. of birds** |
| Black |  |
| Black/white |  |
| Brown |  |
| Brown/black |  |
| Barred |  |
| Others specify |  |

2 Shank colour: Black ( ) Yellow ( ) Black/white ( )

Others (please specify)…………………………..…………………..

3 Beak colour - Black ( )

- White ( )

- Black/white ( )

- Yellow ( )

­- Others (please specify)…………………

4 Measurement Male Female

- Body length (cm)………………………..

- Body circumference (cm)……………….

- Body width (cm)……………………….......

- Wing length (cm)……………………….…

- Shank length (cm)………………………...

- Beak length (cm)……………………….…

- Comb length (cm)…………………….……

- Breast length (cm)…………………….……

- Breast girth (cm)……………………..…….

- Breast Height (cm)…………………..……...

5 Comb types: Walnut ( ) Rose ( ) pea ( ) Single ( )

Comb colours…………………………………………………………

**Special Morphological Feature (Genetic Resource Information)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Total No. of birds per household** | **Pea comb** | **Naked neck** | **Frizzled feathered** | **Silky feathered** | **Normal feathered** | **Dwarf legged** |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

D. Productivity

Growth

Mature body weight (i) Hen……………………… (Kg)

(ii)Cock…………………….. (Kg)

Egg Production: (Data to be collected per household on the basis of hen history)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Mature hen** | **No. of egg laid per clutch** | **No. of eggs incubated** | **No. of chicks hatched** | **No. of eggs wasted** | **No. of chicks weaned** |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

**Hatchability %**

Hatchability (%)………………………………………………………

Average mortality (%): ……………………………………………….

**EGG CHARACTERISTICS**

1. **EXTERNAL**

Average egg weight (g): ……………………………………………....

Egg length (cm): ……………………………………………………....

Egg width (cm): …………………………………………………….…

Shell Thickness………………………………………………………..

Egg Shape Index……………………………………………………….

1. **INTERNAL**

Albumen Width…………………………………………………………

Albumen Height ………………………………....................................

Yolk Length…………………………………………………………….

Yolk Width……………………………………………………….…….

Yolk Index………………………………………………………….…..

Haugh Unit……………………………………………………………..

**E. COLLECTION OF SUBJECTIVE DATA THROUGH THE USE OF PARTICIPATORY RAPID APPRAISAL (PRA) TECHNIQUE**

1 Flock ownership and Managements at household level

Who owns the chicks in the household?

(a) Adult male (> 18 years)

(b) Adult female (> 18 years)

(c) Boys (< 18 years)

(d) Girls (< 18 years)

(e) Collective household ownership

How old are the hens before they can lay egg?

What are the main activities in looking after the chicken?

|  |  |
| --- | --- |
| **Activity** | **Responsibility Member of Household** |
|  |  |
|  |  |
|  |  |
|  |  |

How do you rank the function of the chicken in the village?

(a) Source of food ( ) (b) Source of income ( )

(c) Social functions (ceremonies, gift, rituals) ( )

11 Intra-household level: Movement and Exchange of chicken and chicken products between household: (to be collected in village transect walk).

1 What is the average distance between households (km)?

2 Do the flocks of birds from one household mix with other flocks?

Yes ( ) No. ( )

3 What is the main method of exchanging chicken products?

(a) Sell/buy ( ) (b) Gifts ( ) (c) Food/feast ( )

(d) Barter ( )

4 What is the major source for replacement stock?

(a) Purchase ( ) (b) Hatched chicks ( )

(c) Gifts ( )

(d) Contractual agreement with friends/relatives ( )

5 Where do you sell most of the chickens/products of the village?

(a) In the same village ( ) (b) In neighboring village ( )

(c) In town ( )

1. What are the available scavenging feed resources in the homestead vicinity?

|  |  |  |  |
| --- | --- | --- | --- |
| **Season** | **Type of feed resources** | **Availability (abundant moderate, rare)** | **Nutritional value \*** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

\* Nutritional value from literature or as determined in the laboratory

**Thank you.**

Appendix 2: Body measurements by states (Overall)

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Body\_Length | 14.748a | 5 | 2.950 | 1.042 | .391 |
|  | Body\_Width | 28.631b | 5 | 5.726 | 3.267 | .006 |
|  | Shank\_Length | 53.486c | 5 | 10.697 | 1.591 | .159 |
|  | Wing\_Length | 141.225d | 5 | 28.245 | 6.006 | .000 |
|  | Beak\_Length | 2.138e | 5 | 428 | 2.197 | .052 |
|  | Comb\_Lenght | 3.085f | 5 | 617 | 1.785 | .112 |
|  | Breast\_Height | 47.293g | 5 | 9.459 | 1.752 | .119 |
|  | Breast\_Length | 2.950h | 5 | 590 | 310 | .907 |
| Intercept | Body\_Length | 1790085.566 | 1 | 1790085.566 | 632090.990 | .000 |
|  | Body\_Width | 1589892.033 | 1 | 1589892.033 | 907127.136 | .000 |
|  | Shank\_Length | 421210.007 | 1 | 421210.007 | 62629.060 | .000 |
|  | Wing\_Length | 967618.314 | 1 | 967618.314 | 205749.881 | .000 |
|  | Beak\_Length | 46684.588 | 1 | 46684.588 | 239855.522 | .000 |
|  | Comb\_Length | 33419.570 | 1 | 33419.570 | 96681.895 | .000 |
|  | Breast\_Height | 644472.303 | 1 | 644472.303 | 119368.735 | .000 |
|  | Breast\_Length | 1556740.294 | 1 | 1556740.294 | 817999.616 | .000 |
| State | Body\_Length | 14.748 | 5 | 2.950 | 1.042 | .391 |
|  | Body\_Width | 28.631 | 5 | 5.726 | 3.267 | .006 |
|  | Shank\_Length | 53.486 | 5 | 10.697 | 1.591 | .159 |
|  | Wing\_Length | 141.225 | 5 | 28.697 | 6.006 | .000 |
|  | Beak\_Length | 2.138 | 5 | 428 | 2.197 | .052 |
|  | Comb\_Lenght | 3.085 | 5 | 617 | 1.785 | .112 |
|  | Breast\_Height | 47.293 | 5 | 9.459 | 1.752 | .119 |
|  | Breast\_Length | 2.950 | 5 | 590 | 310 | .907 |
| Error | Body\_Length | 13783.374 | 4867 | 2.832 |  |  |
|  | Body\_Width | 8530.232 | 4867 | 1.753 |  |  |
|  | Shank\_Length | 32732.873 | 4867 | 6.725 |  |  |
|  | Wing\_Length | 22888.948 | 4867 | 4.703 |  |  |
|  | Beak\_Length | 947.295 | 4867 | 195 |  |  |
|  | Comb\_Lenght | 1682.253 | 4867 | 346 |  |  |
|  | Breast\_Height | 26276.954 | 4867 | 5.399 |  |  |
|  | Breast\_Length | 9262.419 | 4867 | 1.903 |  |  |
| Total | Body\_Length | 1841705.339 | 4873 |  |  |  |
|  | Body\_Width | 1632009.359 | 4873 |  |  |  |
|  | Shank\_Length | 463049.609 | 4873 |  |  |  |
|  | Wing\_Length | 1010677.900 | 4873 |  |  |  |
|  | Beak\_Length | 48666.380 | 4873 |  |  |  |
|  | Comb\_Lenght | 35881.440 | 4873 |  |  |  |
|  | Breast\_Height | 682557.230 | 4873 |  |  |  |
|  | Breast\_Length | 1598430.154 | 4873 |  |  |  |

Appendix 3: Body measurements by Sex by states

**Tests of Between-Subject Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Body\_Length | 4725.232a | 1 | 4725.232 | 2536.855 | .000 |
|  | Body\_Width | 567.567b | 1 | 567.567 | 345.954 | .000 |
|  | Shank\_Length | 278.580c | 1 | 278.580 | 41.783 | .000 |
|  | Wing\_Length | 2413.717d | 1 | 2413.717 | 570.283 | .000 |
|  | Beak\_Length | 233.561e | 1 | 233.561 | 1589.214 | .000 |
|  | Comb\_Lenght | 1099.728f | 1 | 1099.728 | 9145.776 | .000 |
|  | Breast\_Height | 1757.065g | 1 | 1757.065 | 348.378 | .000 |
|  | Breast\_Length | 753.224h | 1 | 753.224 | 431.026 | .000 |
| Intercept | Body\_Length | 1831208.543 | 1 | 1831208.543 | 983128.504 | .000 |
|  | Body\_Width | 1618182.122 | 1 | 1618182.122 | 986343.827 | .000 |
|  | Shank\_Length | 429322.720 | 1 | 429322.720 | 64330.170 | .000 |
|  | Wing\_Length | 989212.783 | 1 | 989212.783 | 233718.911 | .000 |
|  | Beak\_Length | 47946.770 | 1 | 47946.770 | 326243.527 | .000 |
|  | Comb\_Lenght | 34952.540 | 1 | 34952.540 | 290679.281 | .000 |
|  | Breast\_Height | 657511.236 | 1 | 657511.236 | 130366.495 | .000 |
|  | Breast\_Length | 1584774.229 | 1 | 1584774.229 | 906873.201 | .000 |
| Sex | Body\_Length | 4725.232 | 1 | 4725.232 | 2536.855 | .000 |
|  | Body\_Width | 567.567 | 1 | 567.567 | 345.954 | .000 |
|  | Shank\_Length | 278.580 | 1 | 278.580 | 41.743 | .000 |
|  | Wing\_Length | 2413.717 | 1 | 2413.717 | 570.283 | .000 |
|  | Beak\_Length | 233.561 | 1 | 233.561 | 1589.214 | .000 |
|  | Comb\_Lenght | 1099.728 | 1 | 1099.728 | 9145.776 | .000 |
|  | Breast\_Height | 1757.065 | 1 | 1757.065 | 348.378 | .000 |
|  | Breast\_Length | 753.224 | 1 | 753.224 | 431.026 | .000 |
| Error | Body\_Length | 9072.890 | 4871 | 1.863 |  |  |
|  | Body\_Width | 7991.296 | 4871 | 1.641 |  |  |
|  | Shank\_Length | 32507.779 | 4871 | 6.674 |  |  |
|  | Wing\_Length | 20616.455 | 4871 | 4.232 |  |  |
|  | Beak\_Length | 715.872 | 4871 | 147 |  |  |
|  | Comb\_Lenght | 585.710 | 4871 | 120 |  |  |
|  | Breast\_Height | 24567.181 | 4871 | 5.044 |  |  |
|  | Breast\_Length | 8512.144 | 4871 | 1.748 |  |  |
| Total | Body\_Length | 1841705.339 | 4873 |  |  |  |
|  | Body\_Width | 1632009.359 | 4873 |  |  |  |
|  | Shank\_Length | 463049.609 | 4873 |  |  |  |
|  | Wing\_Length | 1010677.900 | 4873 |  |  |  |
|  | Beak\_Length | 48666.380 | 4873 |  |  |  |
|  | Comb\_Lenght | 35881.440 | 4873 |  |  |  |
|  | Breast\_Height | 682557.230 | 4873 |  |  |  |
|  | Breast\_Length | 1598430.154 | 4873 |  |  |  |
| Corrected Total | Body\_Length | 13798.122 | 4872 |  |  |  |
|  | Body\_Width | 8558.862 | 4872 |  |  |  |
|  | Shank\_Length | 32786.359 | 4872 |  |  |  |
|  | Wing\_Length | 23030.173 | 4872 |  |  |  |
|  | Beak\_Length | 949.433 | 4872 |  |  |  |
|  | Comb\_Lenght | 1685.438 | 4872 |  |  |  |
|  | Breast\_Height | 26324.246 | 4872 |  |  |  |
|  | Breast\_Length | 9265.368 | 4872 |  |  |  |

1. R Square = 342 (Adjusted R Squared = .342)
2. R Square = 066 (Adjusted R Squared = .066)
3. R Square = 008 (Adjusted R Squared = .008)
4. R Square = 105 (Adjusted R Squared = .105)
5. R Square = 246 (Adjusted R Squared = .246)
6. R Square = 652 (Adjusted R Squared = .652)
7. R Square = 067 (Adjusted R Squared = .067)

Appendix 4: Linear body measurement of indigenous chickens in Benue State (cm)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Parameter** | **Otukpo** | **Okpokwu** | **Gboko** | **Makurdi** | **Vandekya** | **Overall** | **Control** |
| Body length NS | 19.37 ± 0.12 | 19.35 ± 0.13 | 19.29 ± 0.12 | 19.10 ± 0.14 | 19.54 ± 0.12 | 19.34 ± 0.05 | 19.24 ± 0.06 |
| Body width NS | 18.27 ± 0.09 | 18.13 ± 0.10 | 18.26 ± 0.09 | 18.21 ± 0.11 | 18.36 ± 0.11 | 18.25 ± 0.04 | 18.11 ± 0.05 |
| Share length NS | 8.98 ± 0.19 | 9.33 ± 0.25 | 9.46 ± 0.19 | 9.39 ± 0.24 | 9.59 ± 0.21 | 9.34 ± 0.09 | 9.31 ± 0.10 |
| Wing length \* | 14.37 ± 0.15ab | 14.14 ± 0.16abc | 13.48 ± 0.16bc | 13.21 ± 0.18c | 14.69 ± 0.17a | 13.99 ± 0.07 | 14.38 ± 0.08abc |
| Beak length NS | 3.14 ± 0.03 | 3.12 ± 0.03 | 3.07 ± 0.03 | 3.04 ± 0.03 | 3.13 ± 0.03 | 3.10 ±0.16 | 3.09 ± 0.01 |
| Comb length \* | 2.68 ± 0.04ab | 2.60 ± 0.04bc | 2.63 ± 0.04b | 2.51 ± 0.05c | 2.77 ± 0.84a | 2.64 ± 0.02 | 2.58 ± 0.02abc |
| Breast height NS | 11.55 ± 0.17 | 11.51 ± 0.18 | 11.55 ± 0.17 | 11.50 ± 0.20 | 11.73 ± 0.19 | 11.56 ± 0.08 | 11.81 ± 0.09 |
| Breast length NS | 18.02 ± 0.10 | 18.01 ± 0.10 | 17.95 ± 0.10 | 18.02 ± 0.11 | 18.16 ± 0.11 | 18.03 ± 0.04 | 18.00 ± 0.05 |
| Body weight (kg) | 2.09 ± 0.028 | 2.03 ± 0.02ab | 1.96 ± 0.02b | 1.84 ± 0.02c | 1.84 ± 0.02c | 1.95 ± 0.01 | 1.88±0.01 c |

Note: NS = Not significant \* = P < 0.05. Means in row with different superscripts are significantly different.

Appendix 5: Body measurements in Benue by Sex.

|  |  |  |
| --- | --- | --- |
| **Dependent Variable Sex** | **Mean** | **Standard Error** |
| Body length Male  Female | 20.38  18.26 | 0.09  0.09 |
| Body width Male  Female | 18.63  17.85 | 0.08  0.09 |
| Shank length Male  Female | 9.76  8.94 | 0.17  0.17 |
| Wing length Male  Female | 14.68  13.27 | 0.17  0.17 |
| Beak length Male  Female | 3.33  2.87 | 0.02  0.02 |
| comb length Male  Female | 3.14  2.13 | 0.02  0.02 |
| Breast Height Male  Female | 12.14  10.98 | 0.06  0.06 |
| Breast length Male  Female | 18.49  17.57 | 0.09  0.09 |
| Body weight Male  Female | 2.22  1.69 | 0.01  0.01 |

Appendix 6: Body measurements in Benue state by LGA by sex

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Body\_Length | 452.701a | 5 | 90.540 | 54.405 | .000 |
|  | Body\_Width | 61.993b | 5 | 12.399 | 7.725 | .000 |
|  | Shank\_Length | 84.095c | 5 | 16.819 | 2.700 | .021 |
|  | Wing\_Length | 312.950d | 5 | 62.590 | 10.559 | .000 |
|  | Beak\_Length | 21.341e | 5 | 4.268 | 26.355 | .000 |
|  | Comb\_Lenght | 103.396f | 5 | 20.679 | 250.922 | .000 |
|  | Breast\_Height | 136.180g | 5 | 27.236 | 34.278 | .000 |
|  | Breast\_Length | 86.209h | 5 | 17.242 | 9.200 | .000 |
| Intercept | Body\_Length | 149024.518 | 1 | 149024.518 | 89547.022 | .000 |
|  | Body\_Width | 132845.188 | 1 | 132845.188 | 82773.548 | .000 |
|  | Shank\_Length | 34923.419 | 1 | 34923.419 | 5606.133 | .000 |
|  | Wing\_Length | 77934.257 | 1 | 77934.257 | 13147.142 | .000 |
|  | Beak\_Length | 3842.849 | 1 | 3842.849 | 23729.009 | .000 |
|  | Comb\_Lenght | 2774.435 | 1 | 2774.435 | 33665.019 | .000 |
|  | Breast\_Height | 53368.781 | 1 | 53368.781 | 67167.293 | .000 |
|  | Breast\_Length | 129733.672 | 1 | 129733.672 | 69221.088 | .000 |
| LGA | Body\_Length | 1.017 | 4 | .254 | 153 | .962 |
|  | Body\_Width | .825 | 4 | .206 | 129 | .972 |
|  | Shank\_Length | 15.741 | 4 | 3.935 | 632 | .640 |
|  | Wing\_Length | 87.238 | 4 | 21.809 | 3.679 | .006 |
|  | Beak\_Length | .365 | 4 | .091 | 563 | .690 |
|  | Comb\_Lenght | .142 | 4 | .035 | 430 | .058 |
|  | Breast\_Height | .431 | 4 | .108 | 136 | .969 |
|  | Breast\_Length | 1.267 | 4 | .317 | 169 | .954 |
| Sex | Body\_Length | 445.459 | 1 | 445.459 | 267.671 | .000 |
|  | Body\_Width | 59.800 | 1 | 59.800 | 37.260 | .000 |
|  | Shank\_Length | 67.467 | 1 | 67.467 | 10.830 | .001 |
|  | Wing\_Length | 197.701 | 1 | 197.701 | 33.351 | .000 |
|  | Beak\_Length | 20.809 | 1 | 20.809 | 128.494 | .000 |
|  | Comb\_Lenght | 100.712 | 1 | 100.712 | 1222.044 | .000 |
|  | Breast\_Height | 133.686 | 1 | 133.686 | 168.250 | .000 |
|  | Breast\_Length | 84.416 | 1 | 84.416 | 45.041 | .000 |
| Error | Body\_Length | 664.017 | 399 | 1.664 |  |  |
|  | Body\_Width | 640.364 | 399 | 1.605 |  |  |
|  | Shank\_Length | 2485.571 | 399 | 6.230 |  |  |
|  | Wing\_Length | 2365.211 | 399 | 5.928 |  |  |
|  | Beak\_Length | 64.617 | 399 | 162 |  |  |
|  | Comb\_Lenght | 32.883 | 399 | 082 |  |  |
|  | Breast\_Height | 317.031 | 399 | 795 |  |  |
|  | Breast\_Length | 747.803 | 399 | 1.874 |  |  |
| Total | Body\_Length | 152590.693 | 405 |  |  |  |
|  | Body\_Width | 135586.100 | 405 |  |  |  |
|  | Shank\_Length | 37944.930 | 405 |  |  |  |
|  | Wing\_Length | 82004.970 | 405 |  |  |  |
|  | Beak\_Length | 3996.630 | 405 |  |  |  |
|  | Comb\_Lenght | 2967.950 | 405 |  |  |  |
|  | Breast\_Height | 54655.770 | 405 |  |  |  |
|  | Breast\_Length | 132515.937 | 405 |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Appendix 7: Linear body measurement of indigenous chickens in Kogi State (cm)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Parameter** | **Ankpa** | **Okene** | **Idah** | **Omala** | **Adabi** | **Overall** | **Control** |
| Body length NS | 19.54 ± 0.12 | 19.63 ± 0.13 | 19.29 ± 0.12 | 19.10 ± 0.14 | 19.55 ± 0.13 | 19.43 ± 0.05 | 19.24 ± 0.06 |
| Body width NS | 18.55 ± 0.09 | 18.34 ± 0.10 | 18.41 ± 0.09 | 18.21 ± 0.11 | 18.36 ± 0.11 | 18.39 ± 0.04 | 18.11 ± 0.05 |
| Share length NS | 8.96 ± 0.19 | 9.49 ± 0.20 | 9.49 ± 0.19 | 9.39 ± 0.22 | 9.66 ± 0.21 | 9.38 ± 0.09 | 9.31 ± 0.10 |
| Wing length \* | 14.36 ± 0.15ab | 14.17 ± 0.16abc | 13.48 ± 0.16bc | 13.21 ± 0.18c | 14.69 ± 0.17a | 13.99 ± 0.07 | 14.33 ± 0.08abc |
| Beak length NS | 3.18 ± 0.03 | 3.127 ± 0.03 | 3.09 ± 0.03 | 3.04 ± 0.03 | 3.13 ± 0.03 | 3.12 ± 0.01 | 3.09 ± 0.01 |
| Comb length NS | 2.70 ± 0.04 | 2.61 ± 0.04 | 2.63 ± 0.04 | 2.51± 0.05 | 2.77 ± 0.04 | 2.65 ± 0.02 | 2.58 ± 0.02 |
| Breast height NS | 11.82 ± 0.17 | 11.66 ± 0.18 | 11.72 ± 0.17 | 11.58 ± 0.28 | 11.73 ± 0.19 | 11.70 ± 0.08 | 11.81 ± 0.09 |
| Breast length NS | 18.08 ± 0.10 | 18.07 ± 0.10 | 18.01 ± 0.10 | 18.02 ± 0.11 | 18.16 ± 0.11 | 18.06 ± 0.04 | 18.00 ± 0.05 |
| Body weight(kg) | 1.92 ± 0.02 | 1.87 ± 0.02 | 1.85 ± 0.02 | 1.88 ± 0.02 | 1.84 ± 0.02 | 1.87 ± 0.01 | 1.88±0.01 |

Note: NS; Not significant \* = P < 0.05. Means in row with different superscripts are significantly different.

Appendix 8: Body measurements in Kogi state by Sex.

|  |  |  |
| --- | --- | --- |
| **Dependent Variable Sex** | **Mean** | **Standard Error** |
| Body length Male  Female | 20.43  18.39 | 0.09  0.09 |
| Body width Male  Female | 18.82  17.93 | 0.10  0.10 |
| Shank length Male  Female | 9.84  8.95 | 0.17  0.17 |
| Wing length Male  Female | 14.68  13.28 | 0.17  0.17 |
| Beak length Male  Female | 3.35  2.87 | 0.02  0.02 |
| comb length Male  Female | 3.14  2.15 | 0.02  0.02 |
| Breast Height Male  Female | 12.34  11.02 | 0.08  0.08 |
| Breast length Male  Female | 18.56  17.56 | 0.09  0.09 |
| Body weight Male  Female | 2.19  1.55 | 0.01  0.01 |

Appendix 9: Body measurements in Kogi state by LGA by sex in

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Body\_Length | 427.288a | 5 | 85.458 | 45.086 | .000 |
|  | Body\_Width | 83.187b | 5 | 16.633 | 8.014 | .000 |
|  | Shank\_Length | 102.587c | 5 | 20.517 | 3.339 | .006 |
|  | Wing\_Length | 309.659d | 5 | 61.932 | 10.435 | .000 |
|  | Beak\_Length | 23.939e | 5 | 4.788 | 29.957 | .000 |
|  | Comb\_Lenght | 100.806f | 5 | 20.161 | 209.729 | .000 |
|  | Breast\_Height | 176.686g | 5 | 35.338 | 22.495 | .000 |
|  | Breast\_Length | 100.101h | 5 | 20.020 | 10.449 | .000 |
| Intercept | Body\_Length | 150184.137 | 1 | 150184.137 | 79233.998 | .000 |
|  | Body\_Width | 134474.294 | 1 | 134474.294 | 64793.296 | .000 |
|  | Shank\_Length | 35183.424 | 1 | 35183.424 | 5726.139 | .000 |
|  | Wing\_Length | 77851.829 | 1 | 77851.829 | 13116.911 | .000 |
|  | Beak\_Length | 3864.763 | 1 | 3864.763 | 24181.822 | .000 |
|  | Comb\_Lenght | 2789.307 | 1 | 2789.307 | 29015.983 | .000 |
|  | Breast\_Height | 54381.351 | 1 | 54381.351 | 34617.812 | .000 |
|  | Breast\_Length | 129990.617 | 1 | 129990.617 | 67847.190 | .000 |
| LGA | Body\_Length | 10.436 | 4 | 2.609 | 1.376 | .241 |
|  | Body\_Width | 3.697 | 4 | .924 | .445 | .776 |
|  | Shank\_Length | 22.787 | 4 | 5.697 | .927 | .448 |
|  | Wing\_Length | 88.339 | 4 | 22.085 | 3.721 | .005 |
|  | Beak\_Length | .541 | 4 | 135 | 847 | .496 |
|  | Comb\_Lenght | .308 | 4 | 077 | 802 | .524 |
|  | Breast\_Height | 2.453 | 4 | 613 | 390 | .816 |
|  | Breast\_Length | .740 | 4 | 185 | 097 | .984 |
| Sex | Body\_Length | 413.049 | 1 | 413.049 | 217.916 | .000 |
|  | Body\_Width | 78.477 | 1 | 78.477 | 37.812 | .000 |
|  | Shank\_Length | 78.503 | 1 | 78.503 | 12.776 | .000 |
|  | Wing\_Length | 194.273 | 1 | 194.273 | 32.732 | .000 |
|  | Beak\_Length | 23.211 | 1 | 23.211 | 145.233 | .000 |
|  | Comb\_Lenght | 98.055 | 1 | 98.055 | 1020.025 | .000 |
|  | Breast\_Height | 172.378 | 1 | 172.378 | 109.732 | .000 |
|  | Breast\_Length | 99.007 | 1 | 99.007 | 51.675 | .000 |

Appendix 10: Body measurement of indigenous chickens in Nasarawa State (cm)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Parameter** | **Doma** | **Obi** | **Keana** | **Keffi** | **Akwanga** | **Overall** | **Control** |
| Body length NS | 19.35 ± 0.12 | 19.32 ± 0.12 | 19.38 ± 0.12 | 19.35 ± 0.13 | 19.33 ±0.12 | 19.35 ± 0.05 | 19.24 ± 0.66 |
| Body width NS | 18.21 ± 0.09 | 18.17 ± 0.16 | 18.21 ± 0.10 | 18.18 ± 0.10 | 18.21 ± 0.10 | 18.20 ± 0.04 | 18.11 ± 0.05 |
| Share length \* | 9.20 ± 0.19ab | 9.14 ± 0.19b | 10.03 ± 0.19ab | 10.22 ± 0.20a | 9.54 ± 0.19ab | 9.61 ± 0.08 | 9.31 ± 0.10ab |
| Wing length NS | 14.60 ± 0.15 | 14.37 ± 0.16 | 14.29 ± 0.16 | 14.35±0.17 | 14.15 ± 0.16 | 14.35 ± 0.07 | 14.33 ± 0.08 |
| Beak length NS | 3.16 ± 0.03 | 3.14 ± 0.03 | 3.14 ± 0.03 | 3.12 ± 0.05 | 3.14 ± 0.03 | 3.14 ± 0.01 | 3.09 ± 0.01 |
| Comb length NS | 2.68 ± 0.04 | 2.68 ± 0.04 | 2.62 ± 0.04 | 2.66 ± 0.04 | 2.67 ± 0.04 | 2.66 ± 0.02 | 2.55 ± 0.02 |
| Breast height NS | 11.56 ± 0.17 | 11.56 ± 0.17 | 11.55 ± 0.17 | 11.51 ± 0.18 | 11.52± 0.17 | 11.54 ± 0.07 | 11.81 ± 0.09 |
| Breast length NS | 18.09 ± 0.10 | 18.07 ± 0.10 | 18.05 ± 0.10 | 18.08 ± 0.10 | 18.03 ± 0.10 | 18.06 ±0.04 | 18.00 ± 0.05 |
| Body weight (kg) | 1.90 ± 0.02 | 1.88 ± 0.02 | 1.80 ± 0.02 | 1.83 ± 0.02 | 1.85 ± 0.02 | 1.85 ± 0.13 | 1.88±0.00 |

Note: NS = Not significant \* = P < 0.05. Means in row with different superscripts are significantly different.

Appendix 11: Body measurements in Nasarawa state by Sex.

|  |  |  |
| --- | --- | --- |
| **Dependent Variable Sex** | **Mean** | **Standard Error** |
| Body length Male  Female | 20.47  18.19 | 0.08  0.08 |
| Body width Male  Female | 18.56  17.83 | 0.07  0.07 |
| Shank length Male  Female | 9.69  9.56 | 0.18  0.18 |
| Wing length Male  Female | 15.16  13.53 | 0.12  0.12 |
| Beak length Male  Female | 3.37  2.90 | 0.02  0.02 |
| comb length Male  Female | 3.17  2.13 | 0.01  0.01 |
| Breast Height Male  Female | 12.10  10.95 | 0.06  0.06 |
| Breast length Male  Female | 18.44  17.67 | 0.08  0.08 |
| Body weight Male  Female | 2.11  1.60 | 0.01  0.01 |

Appendix 12: Body measurements in Nasarawa state by LGA by sex

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Body\_Length | 566.518a | 5 | 113.304 | 67.981 | .000 |
|  | Body\_Width | 57.631b | 5 | 11.526 | 8.652 | .000 |
|  | Shank\_Length | 82.960c | 5 | 16.592 | 2.256 | .000 |
|  | Wing\_Length | 297.562d | 5 | 59.512 | 18.172 | .000 |
|  | Beak\_Length | 23.416e | 5 | 4.683 | 35.893 | .000 |
|  | Comb\_Lenght | 116.706f | 5 | 23.341 | 299.66 | .000 |
|  | Breast\_Height | 143.074g | 5 | 28.615 | 35.724 | .000 |
|  | Breast\_Length | 64.480h | 5 | 12.896 | 8.036 | .000 |
| Intercept | Body\_Length | 161839.875 | 1 | 161839.875 | 97102.696 | .000 |
|  | Body\_Width | 143342.189 | 1 | 143342.189 | 107599.742 | .000 |
|  | Shank\_Length | 40137.115 | 1 | 40137.115 | 5457.840 | .000 |
|  | Wing\_Length | 89087.806 | 1 | 89087.806 | 27203.462 | .000 |
|  | Beak\_Length | 4264.272 | 1 | 4264.272 | 32682.415 | .000 |
|  | Comb\_Lenght | 3051.048 | 1 | 3051.048 | 39171022 | .000 |
|  | Breast\_Height | 57572.794 | 1 | 57572.794 | 71875601 | .000 |
|  | Breast\_Length | 141263.722 | 1 | 141263.722 | 88031.776 | .000 |
| LGA | Body\_Length | .556 | 4 | .139 | .083 | .988 |
|  | Body\_Width | .141 | 4 | .035 | .026 | .999 |
|  | Shank\_Length | 81.125 | 4 | 20.281 | 2.758 | .028 |
|  | Wing\_Length | 7.382 | 4 | 1.846 | .564 | .689 |
|  | Beak\_Length | .118 | 4 | .030 | .226 | .924 |
|  | Comb\_Lenght | .110 | 4 | .028 | .354 | .841 |
|  | Breast\_Height | .120 | 4 | .030 | .038 | .997 |
|  | Breast\_Length | .103 | 4 | .026 | .016 | .999 |
| Sex | Body\_Length | 566.376 | 1 | 566.376 | 339.821 | .000 |
|  | Body\_Width | 57.536 | 1 | 57.536 | 43.189 | .000 |
|  | Shank\_Length | 2.062 | 1 | 2.062 | .280 | .597 |
|  | Wing\_Length | 287.928 | 1 | 287.928 | 87.920 | .000 |
|  | Beak\_Length | 23.280 | 1 | 23.280 | 178.421 | .000 |
|  | Comb\_Lenght | 116.444 | 1 | 116.444 | 1494.968 | .000 |
|  | Breast\_Height | 142.878 | 1 | 142.878 | 178.373 | .000 |
|  | Breast\_Length | 64.248 | 1 | 64.248 | 40.038 | .000 |

Appendix 13: Body measurement of indigenous chickens in Niger State (cm)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Parameter** | **Bargu** | **Lapal** | **Bida** | **Suleja** | **Kutigi** | **Overall** | **Control** |
| Body length NS | 19.49± 0.12 | 19.34 ± 0.12 | 19.40 ± 0.12 | 19.35 ± 0.12 | 19.38 ± 0.12 | 19.39 ± 0.05 | 19.24 ± 0.06 |
| Body width NS | 18.26 ± 0.10 | 18.20 ± 0.09 | 18.24 ± 0.09 | 18.24 ± 0.09 | 18.29 ± 0.10 | 18.24 ± 0.04 | 18.11 ± 0.05 |
| Share length NS | 9.15 ± 0.19 | 9.53 ± 0.19 | 9.38 ± 0.19 | 9.36 ± 0.19 | 9.43 ± 0.19 | 9.37 ± 0.08 | 9.31 ± 0.10 |
| Wing length NS | 14.35 ± 0.16 | 14.28 ± 0.15 | 14.39 ± 0.16 | 14.18 ±0. 15 | 14.45 ± 0.16 | 14.33 ± 0.07 | 14.33 ± 0.08 |
| Beak length NS | 3.14 ± 0.03 | 3.16 ± 0.03 | 3.15 ± 0.03 | 3.14 ± 0.03 | 3.14 ± 0.03 | 3.15 ± 0.01 | 3.09 ± 0.01 |
| Comb length NS | 2.65 ± 0.04 | 2.65 ± 0.04 | 2.68 ± 0.04 | 2.64 ± 0.04 | 2.67 ± 0.04 | 2.66 ± 0.02 | 2.58 ± 0.02 |
| Breast height NS | 11.56 ± 0.17 | 11.54 ± 0.17 | 11.51 ± 0.17 | 11.53 ± 0.04 | 11.49 ± 0.17 | 11.52 ± 0.07 | 11.81 ± 0.09 |
| Breast length NS | 18.01 ± 0.10 | 18.06 ± 0.10 | 18.10 ± 0.10 | 18.11 ± 0.10 | 18.05 ± 0.10 | 18.07 ± 0.04 | 18.00 ± 0.05 |
| Body weight (kg) | 1.89 ± 0.02 | 1.87 ± 0.02 | 1.89 ± 0.02 | 1.90 ± 0.02 | 1.90 ± 0.02 | 1.89 ± 0.01 | 1.88±0.01 |

Note: NS; Not significant \* p < 0.05. Means in row with different superscripts are significantly different.

Appendix 14: Body measurements in Niger state by Sex.

|  |  |  |
| --- | --- | --- |
| **Dependent Variable Sex** | **Mean** | **Standard Error** |
| Body length Male  Female | 20.42  18.32 | 0.08  0.08 |
| Body width Male  Female | 18.60  17.87 | 0.08  0.08 |
| Shank length Male  Female | 9.58  9.15 | 0.17  0.17 |
| Wing length Male  Female | 15.09  13.53 | 0.11  0.11 |
| Beak length Male  Female | 3.38  2.91 | 0.02  0.02 |
| comb length Male  Female | 3.17  2.12 | 0.01  0.01 |
| Breast Height Male  Female | 12.11  10.91 | 0.05  0.05 |
| Breast length Male  Female | 18.48  17.66 | 0.08  0.08 |
| Body weight Male  Female | 2.19  1.59 | 0.01  0.01 |

Appendix 15: Body measurements in Niger state by LGA by sex

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Body\_Length | 497.749a | 5 | 99.550 | 58.929 | .000 |
|  | Body\_Width | 60.552b | 5 | 12.110 | 7.663 | .000 |
|  | Shank\_Length | 26.962c | 5 | 5.393 | 797 | .552 |
|  | Wing\_Length | 276.681d | 5 | 55.336 | 17.632 | .000 |
|  | Beak\_Length | 24.375e | 5 | 4.875 | 34.105 | .000 |
|  | Comb\_Lenght | 123.026f | 5 | 24.605 | 299.332 | .000 |
|  | Breast\_Height | 162.446g | 5 | 32.489 | 42.197 | .000 |
|  | Breast\_Length | 75.825h | 5 | 15.165 | 9.417 | .000 |
| Intercept | Body\_Length | 168339.915 | 1 | 168339.915 | 99650.037 | .000 |
|  | Body\_Width | 149227.680 | 1 | 149227.680 | 94423.225 | .000 |
|  | Shank\_Length | 39373.564 | 1 | 39373.564 | 5820.095 | .000 |
|  | Wing\_Length | 91956.847 | 1 | 91956.847 | 29299.851 | .000 |
|  | Beak\_Length | 4445.212 | 1 | 4445.212 | 31098.107 | .000 |
|  | Comb\_Lenght | 3152.764 | 1 | 3152.764 | 38354.581 | .000 |
|  | Breast\_Height | 59491.892 | 1 | 59491.892 | 77267.565 | .000 |
|  | Breast\_Length | 146459.311 | 1 | 146459.311 | 90949.300 | .000 |
| LGA | Body\_Length | 1.065 | 4 | .266 | .158 | .959 |
|  | Body\_Width | .286 | 4 | .071 | .045 | .996 |
|  | Shank\_Length | 7.132 | 4 | 1.783 | .264 | .901 |
|  | Wing\_Length | 2.951 | 4 | .738 | .235 | .919 |
|  | Beak\_Length | .034 | 4 | .008 | .059 | .994 |
|  | Comb\_Lenght | .039 | 4 | .010 | .119 | .976 |
|  | Breast\_Height | .338 | 4 | .084 | .110 | .979 |
|  | Breast\_Length | .277 | 4 | .069 | .043 | .996 |
| Sex | Body\_Length | 496.506 | 1 | 496.506 | 293.910 | .000 |
|  | Body\_Width | 60.208 | 1 | 60.208 | 38.096 | .000 |
|  | Shank\_Length | 19.872 | 1 | 19.872 | 2.937 | .087 |
|  | Wing\_Length | 272.940 | 1 | 272.940 | 86.966 | .000 |
|  | Beak\_Length | 24.347 | 1 | 24.347 | 170.331 | .000 |
|  | Comb\_Lenght | 122.940 | 1 | 122.940 | 1495.612 | .000 |
|  | Breast\_Height | 162.217 | 1 | 162.217 | 210.686 | .000 |
|  | Breast\_Length | 75.602 | 1 | 75.602 | 46.948 | .000 |
| Error | Body\_Length | 748.365 | 443 | 1.689 |  |  |
|  | Body\_Width | 700.123 | 443 | 1.580 |  |  |
|  | Shank\_Length | 2996.943 | 443 | 6.765 |  |  |
|  | Wing\_Length | 1390.344 | 443 | 3.138 |  |  |
|  | Beak\_Length | 63.323 | 443 | .143 |  |  |
|  | Comb\_Lenght | 36.415 | 443 | .082 |  |  |
|  | Breast\_Height | 341.086 | 443 | .770 |  |  |
|  | Breast\_Length | 713.381 | 443 | 1.610 |  |  |
| Total | Body\_Length | 170124.295 | 449 |  |  |  |
|  | Body\_Width | 150260.481 | 449 |  |  |  |
|  | Shank\_Length | 42489.514 | 449 |  |  |  |
|  | Wing\_Length | 93901.070 | 449 |  |  |  |
|  | Beak\_Length | 4551.410 | 449 |  |  |  |
|  | Comb\_Lenght | 3340.430 | 449 |  |  |  |
|  | Breast\_Height | 60187.770 | 449 |  |  |  |
|  | Breast\_Length | 147544.205 | 449 |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Appendix 16: Linear body measurements of indigenous chickens in Abuja (cm)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Parameter** | **Kuje** | **Abaji** | **Karshi** | **Bwari** | **Kwali** | **Overall** | **Control** |
| Body length NS | 19.40 ± 0.12 | 19.44 ± 0.12 | 19.41 ± 0.12 | 19.33 ± 0.12 | 19.40 ± 0.13 | 19.40 ± 0.05 | 19.24 ± 0.06 |
| Body width NS | 18.32 ± 0.10 | 18.30 ± 1.10 | 18.27 ± 0.09 | 18.21 ± 0.09 | 18.24 ± 0.10 | 18.27 ± 0.04 | 18.11 ± 0.05 |
| Share length NS | 9.18 ± 0.19 | 9.51 ± 0.19 | 9.39 ± 0.18 | 9.27 ± 0.19 | 9.23 ± 0.20 | 9.32 ± 0.08 | 9.31 ± 0.10 |
| Wing length NS | 14.35 ± 0.16 | 14.53 ± 0.16 | 14.34 ± 0.15 | 14.31 ± 0.15 | 14.40 ± 0.10 | 14.38 ± 0.07 | 14.33 ± 0.08 |
| Beak length NS | 3.14 ± 0.03 | 3.15 ± 0.03 | 3.16 ± 0.03 | 3.13 ± 0.03 | 3.13 ± 0.05 | 3.14 ± 0.01 | 3.09 ± 0.01 |
| Comb length NS | 2.67 ± 0.04 | 2.72 ± 0.04 | 2.66 ± 0.04 | 2.61 ± 0.04 | 2.66 ± 0.04 | 2.66 ± 0.02 | 2.58 ± 0.02 |
| Breast height NS | 11.56 ± 0.17 | 11.58 ± 0.17 | 11.53 ± 0.16 | 11.49 ± 0.17 | 11.54 ± 0.18 | 11.54 ± 0.07 | 11.81± 0.09 |
| Breast length NS | 18.02 ± 0.10 | 18.18 ± 0.10 | 18.09 ± 0.10 | 18.09 ± 0.10 | 17.97 ± 0.10 | 18.07 ± 0.04 | 18.00 ± 0.05 |
| Body weight (kg) NS | 1.89 ± 0.02 | 1.86 ± 0.02 | 1.89 ± 0.02 | 1.84 ± 0.02 | 1.87 ± 0.02 | 1.87 ± 0.01 | 1.88±0.01 |

Note: NS; Not significant

Appendix 17: Body measurements in Abuja area council by Sex**.**

|  |  |  |
| --- | --- | --- |
| **Dependent Variable Sex** | **Mean** | **Standard Error** |
| Body length Male  Female | 20.42  18.31 | 0.08  0.09 |
| Body width Male  Female | 18.59  17.93 | 0.08  0.08 |
| Shank length Male  Female | 9.52  9.09 | 0.16  0.17 |
| Wing length Male  Female | 15.15  13.56 | 0.11  0.12 |
| Beak length Male  Female | 3.38  2.89 | 0.02  0.02 |
| comb length Male  Female | 3.17  2.13 | 0.01  0.01 |
| Breast Height Male  Female | 12.11  10.94 | 0.05  0.06 |
| Breast length Male  Female | 18.46  17.65 | 0.08  0.08 |
| Body weight Male  Female | 2.19  1.55 | 0.01  0.01 |

Appendix 18: Body measurements in Abuja by sex

**Tests of Between – Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sources** | **Dependent**  **Variable** | **Type IV Sum of**  **Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 498.256a  48.707b  26.826c  284.285d  26.796e  121.744f  151.544g  75.639h | 5  5  5  5  5  5  5  5 | 99.651  9.741  5.365  56.857  5.359  24.349  30.309  15.128 | 57.061  6.425  818  18.289  44.751  318.440  38.708  9.021 | .000  .000  .537  .000  .000  .000  .000  .000 |
| Intercept | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 167557.318  149019.451  38734.349  92158.815  4395.704  3140.885  59367.995  145 732.362 | 1  1  1  1  1  1  1  1 | 167557.318  149019.451  38734.349  92158.815  4395.704  3140.885  59367.995  145 732.362 | 95944.363  98292.635  5908.011  29643.733  36704.930  41077.307  75820.313  86900.313 | .000  .000  .000  .000  .000  .000  .000  .000 |
| LGA | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | .241  .426  5.361  .837  .070  .077  .097  1.650 | 4  4  4  4  4  4  4  4 | .060  .107  1.340  .209  .018  .019  .024  .413 | .035  .070  .204  .067  .147  .252  .031  .246 | .998  .991  .936  .992  .964  .909  .998  .912 |
| Sex | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 497.687  48.024  20.710  281.766  26.711  121.162  151.127  73.557 | 1  1  1  1  1  1  1  1 | 497.687  48.024  20.710  281.766  26.711  121.162  151.162  73.557 | 284.978  31.676  3.159  90.633  223.038  1584.582  193.008  43.862 | .000  .000  .000  .000  .000  .000  .000  .000 |
| Error | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 771.909  670.107  2897.859  1374.125  52.933  33.797  346.090  741.237 | 442  442  442  442  442  442  442  442 | 1.746  1.516  6.556  3.109  .120  .076  .783  1.677 |  |  |

Appendix 19: Body measurements for on station (Control)

**Tests of Between – Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sources** | **Dependent**  **Variable** | **Type IV Sum of**  **Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 60.404a  .565b  .084c  39.117d  3.092e  13.173f  439.706g  4.629h | 1  1  1  1  1  1  1  1 | 60.404  .565  .084  39.117  3.092  13.173  439.706  4.629 | 24.165  .305  .012  11.190  18.105  44.266  13.028  2.385 | .000  .581  .913  .001  .000  .000  .000  .124 |
| Intercept | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 47185.828  39304.241  10396.144  26297.779  1245.761  971.250  21277.912  39711.787 | 1  1  1  1  1  1  1  1 | 47185.828  39304.241  10396.144  26297.779  1245.761  971.250  21277.912  39711.787 | 18876.989  21246.999  1477.111  7523.262  7294.396  3263.733  630.429  20457.423 | .000  .000  .000  .000  .000  .000  .000  .000 |
| LGA | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | .000  .000  .000  .000  .000  .000  .000  .000 | 0  0  0  0  0  0  0  0 |  |  |  |
| Sex | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 60.404  .565  .084  39.117  3.092  13.173  439.706  4.629 | 1  1  1  1  1  1  1  1 | 60.404  .565  .084  39.117  3.092  13.173  439.706  4.629 | 24.165  .305  .012  11.190  18.105  44.266  13.028  2.385 | .000  .581  .913  .001  .000  .000  .000  .124 |
| Error | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 737.396  545.712  2076.257  1031.181  50.381  87.789  9956.688  572.652 | 295  295  295  295  295  295  295  295 | 2.500  1.850  7.038  3.496  .171  .298  33.751  1.941 |  |  |
| Total | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 110832.918  98043.475  27827.150  62124.570  2894.205  2085.350  51882.940  96888.459 | 297  297  297  297  297  297  297  297 |  |  |  |
| Corrected Total | Body – Length  Body – Width  Shank – Length  Wing – Length  Break – Length  Comb – Length  Breast – Height  Breast – Length | 797.800  546.277  2076.341  1070.298  53.473  100.962 | 296  296  296  296  296  296 |  |  |  |

Appendix 20: Egg measurements for sites (Overall out/ on station).

**Tests of Between – Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Dependent** | **Type IV Sum of** |  |  |  |  |
| **Sources** | **Variable** | **Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | Egg – Weight | 10.930a | 1 | 10.930 | 1.153 | .283 |
|  | Egg – Length | .007b | 1 | .007 | .052 | .819 |
|  | Egg – Width | .007c | 1 | .007 | .042 | .837 |
|  | Shell – Thickness | 22.677d | 1 | 22.677 | .107 | .744 |
|  | Shell – Weight | .050e | 1 | .050 | .134 | .715 |
|  | Albumen – width | .002f | 1 | .002 | .002 | .964 |
|  | Albumen – Height | 2.912g | 1 | 2.912 | 1.337 | .248 |
|  | Yolk – Width | .002h | 1 | .002 | .002 | .967 |
| Intercept | Egg – Weight | 7860031.577 | 1 | 7860031.577 | 829195.291 | .000 |
|  | Egg – Length | 72564.181 | 1 | 72564.181 | 563735.192 | .000 |
|  | Egg – Width | 75644.719 | 1 | 75644.719 | 479026.075 | .000 |
|  | Shell – Thickness | 3531.881 | 1 | 3531.881 | 16.636 | .000 |
|  | Shell – Weight | 87466.968 | 1 | 87466.968 | 231262.330 | .000 |
|  | Albumen – width | 1764003.735 | 1 | 1764003.735 | 2207850.268 | .000 |
|  | Albumen – Height | 105591.301 | 1 | 105591.301 | 48475.220 | .000 |
|  | Yolk – Width | 814122.380 | 1 | 814122.380 | 588048.978 | .000 |
| Site | Egg – Weight | 10.930 | 1 | 10.930 | 1.153 | .283 |
|  | Egg – Length | .007 | 1 | .007 | .052 | .819 |
|  | Egg – Width | .007 | 1 | .007 | .042 | .837 |
|  | Shell – Thickness | 22.677 | 1 | 22.677 | .107 | .744 |
|  | Shell – Weight | .050 | 1 | .050 | .134 | .715 |
|  | Albumen – width | .002 | 1 | .002 | .002 | .964 |
|  | Albumen – Height | 2.912 | 1 | 2.912 | 1.337 | .248 |
|  | Yolk – Width | .002 | 1 | .002 | .002 | .967 |
| Error | Egg – Weight | 49575.734 | 5230 | 9.479 |  |  |
|  | Egg – Length | 673.207 | 5230 | .129 |  |  |
|  | Egg – Width | 825.888 | 5230 | .-58 |  |  |
|  | Shell – Thickness | 1110351.478 | 5230 | 212.304 |  |  |
|  | Shell – Weight | 1978.006 | 5230 | .378 |  |  |
|  | Albumen – width | 4178.607 | 5230 | .799 |  |  |
|  | Albumen – Height | 11392.264 | 5230 | 2.178 |  |  |
|  | Yolk – Width | 7240.655 | 5230 | 1.384 |  |  |
| Total | Egg – Weight | 8277199.720 | 5332 |  |  |  |
|  | Egg – Length | 76603.010 | 5332 |  |  |  |
|  | Egg – Width | 79959.080 | 5332 |  |  |  |
|  | Shell – Thickness | 1113945.869 | 5332 |  |  |  |
|  | Shell – Weight | 93460.940 | 5332 |  |  |  |
|  | Albumen – width | 1849738.800 | 5332 |  |  |  |
|  | Albumen – Height | 122113.865 | 5332 |  |  |  |
|  | Yolk – Width | 858994.650 | 5332 |  |  |  |
| Corrected Total | Egg – Weight | 49586.664 | 5231 |  |  |  |
|  | Egg – Length | 673.214 | 5231 |  |  |  |
|  | Egg – Width | 825.895 | 5231 |  |  |  |
|  | Shell – Thickness | 1110374.155 | 5231 |  |  |  |
|  | Shell – Weight | 1978.116 | 5231 |  |  |  |
|  | Albumen – Width | 4178.609 | 5231 |  |  |  |
|  | Albumen – Height | 11395.176 | 5231 |  |  |  |
|  | Yolk – Width | 7240.658 | 5231 |  |  |  |

a. R Squared = .000 (Adjusted R Squared = .000)

b. R Squared = .000 (Adjusted R Squared = .000)

c. R Squared = .000 (Adjusted R Squared = .000)

d. R Squared = .000 (Adjusted R Squared = .000)

Appendix 21: Egg measurements by states (Overall).

**Tests of Between – Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Dependent** | **Type IV Sum of** |  |  |  |  |
| **Sources** | **Variable** | **Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | Egg – Weight | 424.369a | 5 | 84.874 | 9.022 | .000 |
|  | Egg – Length | .698b | 5 | .140 | 1.084 | .367 |
|  | Egg – Width | 2.482c | 5 | .496 | 3.150 | .008 |
|  | Shell – Thickness | 5253.818d | 5 | 1050.764 | 4.969 | .000 |
|  | Shell – Weight | 2.943e | 5 | .589 | 1.557 | .169 |
|  | Albumen – width | 6.147f | 5 | 1.229 | 1.540 | .174 |
|  | Albumen – Height | 355.900g | 5 | 71.180 | 33.697 | .000 |
|  | Yolk – Width | 1.405h | 5 | .281 | .203 | .961 |
| Intercept | Egg – Weight | 4210971.909 | 1 | 4210971.909 | 447630.429 | .000 |
|  | Egg – Length | 39248.817 | 1 | 39248.817 | 304995.305 | .000 |
|  | Egg – Width | 41183.457 | 1 | 41183.457 | 261381.272 | .000 |
|  | Shell – Thickness | 3960.544 | 1 | 3960.544 | 18.729 | .000 |
|  | Shell – Weight | 47864.349 | 1 | 47864.349 | 126641.550 | .000 |
|  | Albumen – Width | 957633.271 | 1 | 957633.271 | 1199433.560 | .000 |
|  | Albumen – Height | 53772.825 | 1 | 53772.825 | 25456.087 | .000 |
|  | Yolk – Width | 442097.965 | 1 | 442097.965 | 319149.487 | .000 |
| State | Egg – Weight | 424.369 | 5 | 84.874 | 9.022 | .000 |
|  | Egg – Length | .698 | 5 | .140 | 1.084 | .367 |
|  | Egg – Width | 2.482 | 5 | .496 | 3.150 | .008 |
|  | Shell – Thickness | 5253.818 | 5 | 1050.764 | 4.969 | .000 |
|  | Shell – Weight | 2.943 | 5 | .589 | 1.557 | .169 |
|  | Albumen – width | 6.147 | 5 | 1.229 | 1.540 | .174 |
|  | Albumen – Height | 355.900 | 5 | 71.180 | 33.697 | .000 |
|  | Yolk – Width | 1.405 | 5 | .281 | .203 | .961 |
| Error | Egg – Weight | 49162.295 | 5226 | 9.407 |  |  |
|  | Egg – Length | 672.516 | 5226 | .129 |  |  |
|  | Egg – Width | 823.413 | 5226 | .158 |  |  |
|  | Shell – Thickness | 1105120.337 | 5226 | 211.466 |  |  |
|  | Shell – Weight | 1975.174 | 5226 | .378 |  |  |
|  | Albumen – width | 4172.462 | 5226 | .798 |  |  |
|  | Albumen – Height | 11039.276 | 5226 | 2.112 |  |  |
|  | Yolk – Width | 7239.253 | 5226 | 1.385 |  |  |
| Total | Egg – Weight | 8277199.720 | 5332 |  |  |  |
|  | Egg – Length | 76603.010 | 5332 |  |  |  |
|  | Egg – Width | 79959.080 | 5332 |  |  |  |
|  | Shell – Thickness | 1113945.869 | 5332 |  |  |  |
|  | Shell – Weight | 93460.940 | 5332 |  |  |  |
|  | Albumen – width | 1849738.800 | 5332 |  |  |  |
|  | Albumen – Height | 122113.865 | 5332 |  |  |  |
|  | Yolk – Width | 858994.650 | 5332 |  |  |  |
| Corrected Total | Egg – Weight | 49586.664 | 5231 |  |  |  |
|  | Egg – Length | 673.214 | 5231 |  |  |  |
|  | Egg – Width | 825.895 | 5231 |  |  |  |
|  | Shell – Thickness | 1110374.155 | 5231 |  |  |  |
|  | Shell – Weight | 1978.116 | 5231 |  |  |  |
|  | Albumen – width | 4178.609 | 5231 |  |  |  |
|  | Albumen – Height | 11395.176 | 5231 |  |  |  |
|  | Yolk – Width | 7240.658 | 5231 |  |  |  |

a. R Squared = .009 (Adjusted R Squared = .008)

b. R Squared = .001 (Adjusted R Squared = .000)

c. R Squared = .003 (Adjusted R Squared = .002)

d. R Squared = .005 (Adjusted R Squared = .004)

e. R Squared = .001 (Adjusted R Squared = .001)

f. R Squared = .001 (Adjusted R Squared = .001)

g. R Squared = .031 (Adjusted R Squared = .030)

h. R Squared = .000 (Adjusted R Squared = .001)

Appendix 22: Mean for egg characteristics in Benue State, Nigeria

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Local Government Area** | | | | | | | |
| **Parameter** | **Otukpo** | **Okpokwu** | **Gboko** | **Makurdi** | **Vawekya** | **Grand mean** | **Control** |
| Egg weight NS | 39.30 ± 0.30 | 39.36 ± 0.34 | 38.99 ± 0.36 | 40.56 ± 0.36 | 38.95 ± 0.34 | 39.43 ± 0.36 | 39.86 ± 0.05 |
| Egg length NS | 3.81 ± 0.03 | 3.83 ± 0.04 | 3.81 ± 0.04 | 3.73 ± 0.04 | 3.73 ± 0.04 | 3.78 ± 0.02 | 3.81 ± 0.01 |
| Egg width \*\*\* | 3.85 ± 0.04b | 3.94 ± 0.04b | 4.72 ±0.04a | 3.85 ± 0.04b | 3.87 ± 0.04b | 3.96 ± 0.04 | 3.88 ± 0.01b |
| Shell thickness NS | 0.52 ± 1.45 | 0.52 ± 1.61 | 0.52 ± 1.70 | 0.52 ± 1.70 | 0.52 ± 1.61 | 0.52 ± 1.62 | 0.52 ± 0.25 |
| Shell weight \* | 4.18 ± 0.06b | 4.16 ± 0.06b | 4.53 ± 0.07a | 4.18 ± 0.07b | 4.11 ± 0.06b | 4.23 ± 0.06 | 4.16 ± 0.01b |
| Albumen width NS | 18.75 ± 0.09 | 18.72 ± 0.10 | 18.88 ± 0.10 | 18.78 ± 0.10 | 18 .76 ± 0.10 | 18.78 ± 0.10 | 18.77 ± 0.01 |
| Albumen height NS | 4.61 ± 0.14 | 4.55 ± 0.15 | 4.53 ± 0.16 | 4.50 ± 0.16 | 4.64 ± 0.15 | 4.56 ± 0.16 | 4.71 ± 0.02 |
| Yolk width NS | 12.75 ± 0.11 | 12.76 ± 0.13 | 12.80 ± 0.13 | 12.80 ± 0.13 | 12.67 ± 0.13 | 12.76 ± 0.13 | 12.75 ± 0.02 |

Note: NS = Not significant Significant at \* = P<0.05; \*\*\* = P < 0.001). Means in row with different superscripts are significantly different.

Appendix 23: Egg measurements for Benue in out-station.

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Egg Weight | 62.842a | 4 | 15.710 | 1,820 | .127 |
|  | Egg Length | .346b | 4 | .087 | .623 | .646 |
|  | Egg Width | 4.709c | 4 | 1.177 | 5.972 | .000 |
|  | Shell Thickness | .002d | 4 | .000 | .054 | .994 |
|  | Shell Weight | .4071e | 4 | 1,018 | 2.492 | .044 |
|  | Albumen Width | .587f | 4 | 147 | .211 | .932 |
|  | Albumen Height | .536g | 4 | .134 | .543 | .770 |
|  | Yolk Width | .404h | 4 | 101 | .094 | .984 |
| Intercept | Egg Weight | 308698.229 | 1 | 308698.229 | 35755.852 | .000 |
|  | Egg Length | 2844.804 | 1 | 2844.804 | 20489.754 | .000 |
|  | Egg Width | 3112.854 | 1 | 3112.854 | 15792.675 | .000 |
|  | Shell Thickness | 54.691 | 1 | 54.691 | 7656.443 | .000 |
|  | Shell Weight | 3564.452 | 1 | 3564.452 | 8726.624 | .000 |
|  | Albumen Width | 70033.498 | 1 | 70033.498 | 100781.636 | .000 |
|  | Albumen Height | 4142.346 | 1 | 4142.346 | 13997.400 | .000 |
|  | Yolk Width | 32316.653 | 1 | 32316.653 | 30179.022 | .000 |
| LGA | Egg Weight | 62.842 | 4 | 15.710 | 1.820 | .127 |
|  | Egg Length | .346 | 4 | .087 | .623 | .646 |
|  | Egg Width | 4.709 | 4 | 1.177 | 5.972 | .000 |
|  | Shell Thickness | .002 | 4 | .000 | .054 | .994 |
|  | Shell Weight | 4.701 | 4 | 1.018 | 2.492 | .044 |
|  | Albumen Width | .587 | 4 | .147 | .211 | .932 |
|  | Albumen Height | .536 | 4 | .134 | .453 | .770 |
|  | Yolk Width | .404 | 4 | .101 | .094 | .984 |
| Error | Egg Weight | 1692.166 | 196 | 8.634 |  |  |
|  | Egg Length | 27.213 | 196 | .139 |  |  |
|  | Egg Width | 38.633 | 196 | .197 |  |  |
|  | Shell Thickness | 1.400 | 196 | .007 |  |  |
|  | Shell Weight | 80.058 | 196 | .408 |  |  |
|  | Albumen Width | 136.201 | 196 | .695 |  |  |
|  | Albumen Height | 58.004 | 196 | 296 |  |  |
|  | Yolk Width | 209.883 | 196 | 1,071 |  |  |
| Total | Egg Weight | 314078.880 | 201 |  |  |  |
|  | Egg Length | 2911.030 | 201 |  |  |  |
|  | Egg Width | 3182.210 | 201 |  |  |  |
|  | Shell Thickness | 56.724 | 201 |  |  |  |
|  | Shell Weight | 3682.040 | 201 |  |  |  |
|  | Albumen Width | 71035.420 | 201 |  |  |  |
|  | Albumen Height | 4261.250 | 201 |  |  |  |
|  | Yolk Width | 32929.990 | 201 |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Appendix 24: Mean for egg characteristics in Kogi State, Nigeria

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Local Government Area** | | | | | | | |
| **Parameter** | **Ankpa** | **Okene** | **Idah** | **Omala** | **Adabi** | **Grand mean** | **Control** |
| Egg weight NS | 39.37 ± 0.05 | 39.21 ± 0.34 | 38.78 ± 0.33 | 40.29 ± 0.34 | 38.97 ± 0.34 | 39.33 ± 0.04 | 39.86 ± 0.05 |
| Egg length NS | 3.82 ± 0.06 | 3.81 ± 0.04 | 3.76 ± 0.03 | 3.76 ± 0.04 | 3.77 ± 0.04 | 3.78 ± 0.04 | 3.81 ± 0.01 |
| Egg width NS | 3.84 ± 0.06 | 3.90 ± 0.04 | 3.89 ± 0.04 | 3.89 ± 0.04 | 3.89 ± 0.04 | 3.88 ± 0.04 | 3.88 ± 0.01 |
| Shell thickness NS | 0.54 ± 2.97 | 0.53 ± 1.61 | 0.53 ± 1.57 | 0.51 ± 1.61 | 0.52 ± 1.61 | 0.53 ± 1.72 | 0.52 ± 0.25 |
| Shell weight NS | 4.37 ± 0.10 | 4.17 ± 0.06 | 4.06 ± 0.06 | 4.16 ± 0.06 | 4.28 ± 0.06 | 4.21 ± 0.71 | 4.16 ± 0.01 |
| Albumen width NS | 18.72 ± 0.15 | 18.86 ± 0.10 | 18.76 ± 0.09 | 18.30 ± 0.10 | 18.84 ± 0.10 | 18.70 ± 0.12 | 18.77 ± 0.01 |
| Albumen height \*\*\* | 4.58 ± 0.23a | 4.87 ± 0.15ab | 4.56 ± 0.15a | 4.58 ± 0.15a | 4.50 ± 0.15a | 4.63 ± 0.22 | 4.71 ± 0.02a |
| Yolk width NS | 12.77 ± 0.20 | 12.73 ± 0.13 | 12.65 ± 0.12 | 12.70 ± 0.13 | 12.73 ± 0.13 | 12.72 ± 0.13 | 12.75 ± 0.02 |

Note: NS = Not significant Significant at \*\*\* = P < 0.001). Means in row with different superscripts are significantly different.

Appendix 25: Egg measurements for Kogi out-station.

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Egg Weight | 55.270a | 4 | 13.817 | 1.359 | .250 |
|  | Egg Length | .099b | 4 | .025 | .159 | .959 |
|  | Egg Width | 053c | 4 | .013 | .073 | .990 |
|  | Shell Thickness | .019d | 4 | .005 | .653 | .626 |
|  | Shell Weight | 1.554e | 4 | .388 | .780 | .540 |
|  | Albumen Width | 8.496f | 4 | 2.124 | .996 | .411 |
|  | Albumen Height | .519.855g | 4 | 129.964 | 632.621 | .000 |
|  | Yolk Width | .234h | 4 | .058 | .051 | .995 |
| Intercept | Egg Weight | 245341.956 | 1 | 245341.956 | 24125.560 | .000 |
|  | Egg Length | 2274.505 | 1 | 2274.505 | 14688.330 | .000 |
|  | Egg Width | 2395.280 | 1 | 2395.280 | 13042.393 | .000 |
|  | Shell Thickness | 44.715 | 1 | 44.715 | 6183.713 | .000 |
|  | Shell Weight | 2812.912 | 1 | 2812.912 | 5646.846 | .000 |
|  | Albumen Width | 55458.235 | 1 | 55458.235 | 26004.315 | .000 |
|  | Albumen Height | 2242.410 | 1 | 2242.410 | 10915.318 | .000 |
|  | Yolk Width | 25672.900 | 1 | 25672.900 | 22225.474 | .000 |
| LGA | Egg Weight | 55.270 | 4 | 13.817 | 1.359 | .250 |
|  | Egg Length | .099 | 4 | .025 | 159 | .959 |
|  | Egg Width | .053 | 4 | .013 | 073 | .990 |
|  | Shell Thickness | .019 | 4 | .005 | 653 | .626 |
|  | Shell Weight | 1.554 | 4 | .388 | 780 | .540 |
|  | Albumen Width | 8.496 | 4 | 2.124 | 996 | .411 |
|  | Albumen Height | 519.855 | 4 | 129.964 | 632.621 | .000 |
| Appendix 25 (Contd.): Egg measurements for Kogi out-station. | Yolk Width | .234 | 4 | .058 | .051 | .995 |
| Error | Egg Weight | 1769.472 | 174 | 10.169 |  |  |
|  | Egg Length | 26.944 | 174 | .155 |  |  |
|  | Egg Width | 31.956 | 174 | .184 |  |  |
|  | Shell Thickness | 1.258 | 174 | .007 |  |  |
|  | Shell Weight | 86.676 | 174 | .498 |  |  |
|  | Albumen Width | 371.082 | 174 | 2.133 |  |  |
|  | Albumen Height | 35.746 | 174 | .205 |  |  |
|  | Yolk Width | 200.989 | 174 | 1.155 |  |  |
| Total | Egg Weight | 278563.620 | 179 |  |  |  |
|  | Egg Length | 2587,540 | 179 |  |  |  |
|  | Egg Width | 2743.690 | 179 |  |  |  |
|  | Shell Thickness | 51.410 | 179 |  |  |  |
|  | Shell Weight | 3229.850 | 179 |  |  |  |
|  | Albumen Width | 62951.650 | 179 |  |  |  |
|  | Albumen Height | 2958.027 | 179 |  |  |  |
|  | Yolk Width | 29145.840 | 179 |  |  |  |
| Corrected Total | Egg Weight | 1824.7842 | 178 |  |  |  |
|  | Egg Length | 27.043 | 178 |  |  |  |
|  | Egg Width | 32.009 | 178 |  |  |  |
|  | Shell Thickness | 1.277 | 178 |  |  |  |
|  | Shell Weight | 88.230 | 178 |  |  |  |
|  | Albumen Width | 379.578 | 178 |  |  |  |
|  | Albumen Height | 55.601 | 178 |  |  |  |
|  | Yolk Width | 201.223 | 178 |  |  |  |

Appendix 26: Mean for egg characteristics in Nasarawa State, Nigeria

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Local Government Area** | | | | | | | |
| **Parameter** | **Doma** | **Obi** | **Keana** | **Keffi** | **Akwanga** | **Grand mean** | **Control** |
| Egg weight NS | 39.60 ± 0.34 | 39.21 ± 0.32 | 39.11 ± 0.36 | 40.15 ± 0.36 | 38.81 ± 0.34 | 39.38 ± 0.35 | 39.86 ± 0.05 |
| Egg length NS | 3.81 ± 0.04 | 3.80 ± 0.03 | 3.77 ± 0.04 | 3.47 ± 0.04 | 3.80 ± 0.04 | 3.73 ± 0.04 | 3.81 ± 0.01 |
| Egg width NS | 3.89 ± 0.04 | 3.87 ± 0.04 | 3.88 ± 0.04 | 3.86 ± 0.04 | 3.72 ± 0.04 | 3.84 ± 0.04 | 3.88 ± 0.01 |
| Shell thickness NS | 0.52 ±1.61 | 0.73 ± 1.52 | 0.53 ± 1.77 | 0.53 ± 1.70 | 0.52 ± 1.61 | 0.57 ± 1.66 | 0.52 ± 0.25 |
| Shell weight NS | 4.12 ± 0.06 | 4.24 ± 0.06 | 4.15 ± 0.07 | 4.20 ± 0.07 | 4.18 ± 0.06 | 4.18 ± 0.06 | 4.18 ± 0.01 |
| Albumen Height NS | 4.39 ± 0.15 | 4.56 ± 0.14 | 4.60 ± 0.17 | 4.56 ± 0.16 | 4.57 ± 0.15 | 4.54 ± 0.15 | 4.71 ± 0.02 |
| Albumen Width NS | 18.83 ± 0.10 | 18.62 ± 0.05 | 18.79 ± 0.11 | 18.70 ± 0.10 | 18.83 ± 0.10 | 18.758± 0.10 | 18.77 ± 0.01 |
| Yolk width NS | 12.78 ± 0.13 | 12.73 ± 0.12 | 12.85 ± 0.14 | 12.83 ± 0.13 | 12.76 ± 0.13 | 12.79 ± 0.13 | 12.75± 0.02 |

Note: NS = Not significant.

Appendix 27: Egg measurements for Nasarawa in out-station**.**

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Egg- Weight | 42.063a | 4 | 10.516 | 1.042 | .235 |
|  | Egg- Length | 056b | 4 | 014 | 134 | .985 |
|  | Egg- Width | 795c | 4 | 199 | 1.272 | .345 |
|  | Shell- Thickness | 9416.672d | 4 | 2354.168 | 1.403 | .512 |
|  | Shell- Weight | 340e | 4 | 085 | 215 | .930 |
|  | Albumen- Width | 1.360f | 4 | 340 | 435 | .783 |
|  | Albumen- Height | 1.047g | 4 | 262 | 796 | .529 |
|  | Yolk- Width | 345h | 4 | 086 | 080 | .988 |
| Intercept | Egg- Weight | 297628.705 | 1 | 297628.705 | 39707.030 | .000 |
|  | Egg- Length | 2762.201 | 1 | 2762.201 | 1855.968 | .000 |
|  | Egg- Width | 2839.138 | 1 | 2839.138 | 16110.839 | .000 |
|  | Shell- Thickness | 2815.857 | 1 | 2815.857 | 985 | .322 |
|  | Shell- Weight | 3355.155 | 1 | 3355.155 | 8486.599 | .000 |
|  | Albumen- Width | 67512.987 | 1 | 67512.987 | 86426.307 | .000 |
|  | Albumen- Height | 3956.469 | 1 | 3956.469 | 12035.096 | .000 |
|  | Yolk- Width | 31412.717 | 1 | 31412.717 | 29070.182 | .000 |
| LGA | Egg- Weight | 42063 | 4 | 10.516 | 1403 |  |
|  | Egg- Length | 056 | 4 | 014 | 093 |  |
|  | Egg- Width | 795 | 4 | 199 | 1.128 |  |
|  | Shell- Thickness | 9416.672 | 4 | 2354.168 | 823 |  |
|  | Shell- Weight | 340 | 4 | 085 | 215 |  |
|  | Albumen- Width | 1.360 | 4 | 340 | 435 |  |
|  | Albumen- Height | 1.047 | 4 | 262 | 796 |  |
|  | Yolk- Width | 345 | 4 | 086 | 086 |  |
| Error | Egg- Weight | 1416.672 | 189 | 189 | 7.496 |  |
|  | Egg- Length | 28.441 | 189 | 189 | 150 |  |
| Appendix 27 (Contd.): Egg measurements for Nasarawa in out-station**.** | Egg- Width | 33.307 | 189 | 176 | 176 |  |
|  | Shell- Thickness | 540489.219 | 189 | 2859.7 | 2859.731 |  |
|  | Shell- Weight | 74.721 | 189 | 395 | 395 |  |
|  | Albumen- Width | 147.640 | 189 | 781 | 781 |  |
|  | Albumen- Height | 62.133 | 189 | 329 | 329 |  |
|  | Yolk- Width | 204.230 | 189 | 1.081 | 1.081 |  |
| Total | Egg- Weight | 302143.960 | 194 |  |  |  |
|  | Egg- Length | 2823.780 | 194 |  |  |  |
|  | Egg- Width | 2903.510 | 194 |  |  |  |
|  | Shell- Thickness | 553590.789 | 194 |  |  |  |
|  | Shell- Weight | 3471.230 | 194 |  |  |  |
|  | Albumen- Width | 68389.630 | 194 |  |  |  |
|  | Albumen- Height | 4059.470 | 194 |  |  |  |

Appendix 28: Mean for egg characteristics in Niger State, Nigeria

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Local Government Area** | | | | | | | |
| **Parameter** | **Bargu** | **Lapal** | **Bida** | **Suleja** | **Kutigi** | **Grand mean** | **Control** |
| Egg weight \* | 38.98 ± 0.35ab | 38.16 ± 0.35b | 39.23 ± 0.34ab | 40.28 ± 0.34a | 38.95 ± 0.34ab | 39.12 ± 0.35 | 39.18 ± 0.05ab |
| Egg length NS | 3.73 ± 0.04 | 3.83 ± 0.04 | 3.83 ± 0.04 | 3.83 ± 0.04 | 3.82 ± 0.04 | 3.81 ± 0.04 | 3.81 ± 0.01 |
| Egg width NS | 3.81 ± 0.04 | 3.89 ± 0.04 | 3.92 ± 0.04 | 3.92 ± 0.04 | 3.93 ± 0.04 | 3.90 ± 0.04 | 3.88 ± 0.01 |
| Shell thickness NS | 0.91 ± 1.67 | 0.52 ± 1.65 | 0.52 ± 1.61 | 0.52 ± 1.61 | 0.52 ± 1.60 | 0.60 ± 1.62 | 0.52 ± 0.25 |
| Shell weight NS | 4.22 ± 0.07 | 4.26 ±0.07 | 4.23 ± 0.06 | 4.23 ± 0.06 | 4.23 ± 0.06 | 4.23 ± 0.06 | 4.16 ± 0.01 |
| Albumen width NS | 18.88 ± 0.10 | 18.76 ± 0.10 | 18.88 ± 0.10 | 18.88 ± 0.10 | 18.88 ± 0.10 | 18.85 ± 0.10 | 18.77 ± 0.16 |
| Albumen height NS | 4.52 ± 0.16 | 4.46 ± 0.15 | 4.65 ± 0.15 | 4.65 ± 0.15 | 4.66 ± 0.55 | 4.59 ± 0.15 | 4.71 ± 0.02 |
| Yolk width NS | 12.82 ± 0.13 | 12.84 ± 0.13 | 12.76 ± 0.13 | 12.76 ± 0.13 | 12.74 ± 0.13 | 12.78 ± 0.13 | 12.75 ± 0.12 |

Note: NS = Not significant Significant at \* = P < 0.05. Means in row with different superscripts are significantly different.

Appendix 29: Egg measurements for Niger in out-station

**.**

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Egg Weight | 91.422a | 4 | 22.855 | 3.115 | .016 |
|  | Egg Length | .287b | 4 | .072 | .488 | .745 |
|  | Egg Width | .377c | 4 | .094 | .657 | .622 |
|  | Shell Thickness | 58.179d | 4 | 14.545 | 1.071 | .372 |
|  | Shell Weight | .037e | 4 | .009 | .024 | .999 |
|  | Albumen Width | .463f | 4 | .166 | .165 | .956 |
|  | Albumen Height | .1.225g | 4 | .306 | 1.179 | .321 |
|  | Yolk Width | .310h | 4 | .077 | .071 | .991 |
| Intercept | Egg Weight | 298162.335 | 1 | 298162.335 | 40631.280 | .000 |
|  | Egg Length | 2831.159 | 1 | 2831.159 | 19267.352 | .000 |
|  | Egg Width | 2963.817 | 1 | 2963.817 | .20686.050 | .000 |
|  | Shell Thickness | 125.894 | 1 | 125.894 | 9.274 | .000 |
|  | Shell Weight | 3498.673 | 1 | 3498.673 | 8924.976 | .000 |
|  | Albumen Width | 69278.947 | 1 | 69278.947 | 98890.155 | .000 |
|  | Albumen Height | 4106.643 | 1 | 4106.643 | 15805.269 | .000 |
|  | Yolk Width | 31853.707 | 1 | 31853.707 | 29286.450 | .000 |
| LGA | Egg Weight | 91.422 | 4 | 22.855 | 3.115 | .016 |
|  | Egg Length | .287 | 4 | .072 | .488 | .745 |
|  | Egg Width | .377 | 4 | .094 | .657 | .622 |
|  | Shell Thickness | 58.179 | 4 | 14.545 | 1.071 | .372 |
|  | Shell Weight | .037 | 4 | .009 | .024 | .999 |
|  | Albumen Width | .463 | 4 | .116 | .165 | .956 |
|  | Albumen Height | 1.225 | 4 | .306 | 1.179 | .321 |
|  | Yolk Width | .310 | 4 | .077 | .071 | .991 |
| Error | Egg Weight | 1769.472 | 190 | 7.338 |  |  |
|  | Egg Length | 26.944 | 190 | .147  Appendix 29 (Contd.): Egg measurements for Niger in out-station |  |  |
|  | Egg Width | 31.956 | 190 | .143 |  |  |
|  | Shell Thickness | 1.258 | 190 | 13.575 |  |  |
|  | Shell Weight | 86.676 | 190 | .392 |  |  |
|  | Albumen Width | 371.082 | 190 | .701 |  |  |
|  | Albumen Height | 35.746 | 190 | .260 |  |  |
|  | Yolk Width | 200.989 | 190 | 1.088 |  |  |
| Total | Egg Weight | 300151.290 | 195 |  |  |  |
|  | Egg Length | 2863.800 | 195 |  |  |  |
|  | Egg Width | 2996.670 | 195 |  |  |  |
|  | Shell Thickness | 2759.014 | 195 |  |  |  |
|  | Shell Weight | 3576.760 | 195 |  |  |  |
|  | Albumen Width | 69491.220 | 195 |  |  |  |
|  | Albumen Height | 4165.760 | 195 |  |  |  |
|  | Yolk Width | 32089.240 | 195 |  |  |  |
| Corrected Total | Egg Weight | 1485.689 | 194 |  |  |  |
|  | Egg Length | 28.205 | 194 |  |  |  |
|  | Egg Width | 27.599 | 194 |  |  |  |
|  | Shell Thickness | 2637.425 | 194 |  |  |  |
|  | Shell Weight | 74.519 | 194 |  |  |  |
|  | Albumen Width | 133.570 | 194 |  |  |  |
|  | Albumen Height | 50.593 | 194 |  |  |  |
|  | Yolk Width | 206.965 | 194 |  |  |  |

1. R Squared = .062 (Adjusted R Squared = .042)
2. R Squared = .010 (Adjusted R Squared = .011)
3. R Squared = .014 (Adjusted R Squared= .007)
4. R Squared = .022 (Adjusted R Squared = .001)
5. R Squared = .001 (Adjusted R Squared= .021)
6. R Squared = 003 (Adjusted R Squared = .018)
7. R Squared = .024 (Adjusted R Squared = .004).

Appendix 30: Mean for egg characteristics in Abuja State, Nigeria

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean ±Standard Error** | | | | | | | |
| **Local Government Area** | | | | | | | |
| **Parameter** | **Kuje** | **Abaji** | **Karshi** | **Bwari** | **Kwali** | **Grand mean** | **Control** |
| Egg weight \* | 39.26 ± 0.34a | 38.52 ± 0.34a | 39.23 ± 0.36a | 40.29 ± 0.34a | 38.82 ± 0.33a | 39.23 ± 0.34 | 39.86 ± 0.05a |
| Egg length NS | 3.83 ± 0.04 | 3.83 ± 0.04 | 3.84 ± 0.04 | 3.79 ± 0.04 | 3.80 ± 0.03 | 3.82 ± 0.04 | 3.18 ± 0.01 |
| Egg width NS | 3.92 ± 0.04 | 3.92 ± 0.04 | 3.86 ± 0.04 | 3.79 ± 0.04 | 3.96 ± 0.04 | 3.89 ± 0.04 | 3.88 ± 0.01 |
| Shell thickness NS | 0.52 ± 1.61 | 0.53 ± 1.60 | 0.53 ± 1.70 | 0.52 ± 1.63 | 0.52 ± 1.57 | 0.52 ± 1.62 | 0.52 ± 0.02 |
| Shell weight NS | 4.23 ± 0.06a | 4.23 ± 0.06a | 4.13 ± 0.73a | 4.20 ± 0.70a | 4.12 ± 0.06a | 4.18 ± 0.06 | 4.16 ± 0.05 |
| Albumen width NS | 18.88 ± 0.10 | 18.88 ± 0.10 | 18.74 ± 0.10 | 18.82 ± 0.10 | 18.81 ± 0.09 | 18.82 ± 0.10 | 18.77 ± 0.01 |
| Albumen height NS | 4.65 ± 0.15 | 4.66 ± 0.15 | 4.58 ± 0.16 | 4.60 ± 0.15 | 4.62 ± 0.15 | 4.62 ± 0.15 | 4.71 ± 0.02 |
| Yolk width NS | 12.76 ± 0.13 | 12.76 ± 0.13 | 12.86 ± 0.13 | 12.73 ± 0.13 | 12.71 ± 0.12 | 12.76 ± 0.13 | 12.75 ± 0.02 |

Note: NS = Not significant Significant at \* = P < 0.05. Means in row with different superscripts are significantly different.

Appendix 31: Egg measurements for Abuja in out -station.

**Tests of Between-Subjects Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Dependent variable** | **Type IV Sum of Square** | **Df** | **Mean Square** | **F** | **Sig** |
| Corrected Model | Egg- Weight | 71.351a | 4 | 17.838 | 1.042 | .058 |
|  | Egg- Length | 074b | 4 | 018 | 134 | .970 |
|  | Egg- Width | 705c | 4 | 176 | 1.272 | .282 |
|  | Shell- Thickness | 002d | 4 | 000 | 054 | .000.995 |
|  | Shell- Weight | 427e | 4 | 107 | 273 | .895 |
|  | Albumen- Width | 519f | 4 | 130 | 179 | .948 |
|  | Albumen- Height | 134g | 4 | 033 | 124 | .974 |
|  | Yolk- Width | 478h | 4 | 120 | 115 | .977 |
| Intercept | Egg- Weight | 302375.052 | 1 | 302375.052 | 39320.477 | .000 |
|  | Egg- Length | 2871.455 | 1 | 2871.455 | 20798.380 | .000 |
|  | Egg- Width | 2979.753 | 1 | 2979.753 | 21498.745 | .000 |
|  | Shell- Thickness | 54.373 | 1 | 54.373 | 7570.431 | .000 |
|  | Shell- Weight | 3443.939 | 1 | 3443.939 | 8821.339 | .000 |
|  | Albumen- Width | 69655.613 | 1 | 69655.613 | 96221.429 | .000 |
|  | Albumen- Height | 4205.955 | 1 | 4205.955 | 15608.249 | .000 |
|  | Yolk- Width | 32034.802 | 1 | 32034.802 | 30734.368 | .000 |
| LGA | Egg- Weight | 71.351 | 4 | 17.838 | 2.320 | .058 |
|  | Egg- Length | 074 | 4 | 018 | 134 | .970 |
|  | Egg- Width | 705 | 4 | 176 | 1.272 | .282 |
|  | Shell- Thickness | 002 | 4 | 000 | 054 | .995 |
|  | Shell- Weight | 427 | 4 | 107 | 273 | .895 |
|  | Albumen- Width | 519 | 4 | 130 | 179 | .949 |
|  | Albumen- Height | 134 | 4 | 033 | 124 | .974 |
|  | Yolk- Width | 478 | 4 | 120 | 115 | .977 |
| Error  Appendix 31(Contd.): Egg measurements for Abuja in out -station. | Egg- Weight | 1476.483 | 192 | 7.690 |  |  |
|  | Egg- Length | 26.508 | 192 | 138 |  |  |
|  | Egg- Width | 26.611 | 192 | 139 |  |  |
|  | Shell- Thickness | 1.379 | 192 | 007 |  |  |
|  | Shell- Weight | 74.959 | 192 | 390 |  |  |
|  | Albumen- Width | 138.991 | 192 | 724 |  |  |
|  | Albumen- Height | 51.738 | 192 | 269 |  |  |
|  | Yolk- Width | 200.124 | 192 | 1.042 |  |  |
| Total | Egg- Weight | 304548.220 | 197 |  |  |  |
|  | Egg- Length | 29048.800 | 197 |  |  |  |
|  | Egg- Width | 3017.450 | 197 |  |  |  |
|  | Shell- Thickness | 55.873 | 197 |  |  |  |
|  | Shell- Weight | 3528.660 | 197 |  |  |  |
|  | Albumen- Width | 69985.440 | 1967 |  |  |  |
|  | Albumen- Height | 4270.220 | 197 |  |  |  |
|  | Yolk- Width | 32305.790 | 197 |  |  |  |

Appendix 32: Body weight comparison for sites (Out/ On-station)

**Test of Between- Subjects Effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Type IV Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | 4.813E-5a | 1 | 4.813E-5 | .000 | .987 |
| Intercept | 40174.879 | 1 | 40174.879 | 228594.283 | .000 |
| Site | 4.813E-5 | 1 | 4.813E-5 | .000 | .987 |
| Error | 1980.147 | 11267 | .176 |  |  |
| Total | 42158.540 | 11269 |  |  |  |
| Corrected Total | 1980 | 11268 |  |  |  |

1. R Squared = .000 (Adjusted R squared= .000)

Appendix 33: Body weight comparison by states (Overall)

**Test of Between- Subjects Effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Type IV Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | 7.844a | 5 | 1.569 | 8.958 | .000 |
| Intercept | 28456.133 | 1 | 28456.133 | 162501.059 | .000 |
| State | 7.844 | 5 | 1.569 | 8.958 | .000 |
| Error | 1972.304 | 11263 | .175 |  |  |
| Total | 42158.540 | 11269 |  |  |  |
| Corrected Total | 1980.147 | 11268 |  |  |  |

1. R Squared= .004 (Adjusted R Squared = .004)

Appendix 34: Body weight comparison in Benue by LGA by sex (out-station**)**

**Test of Between- Subjects Effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Type IV Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | 47.974a | 5 | 9.595 | 101.189 | .000 |
| Intercept | 2301.433 | 1 | 2301.433 | 24271.666 | .000 |
| LGA | 5.998 | 4 | 1.499 | 15.813 | .000 |
| Sex | 41.976 | 1 | 41.976 | 442.694 |  |
| Error | 56.232 | 594 | .095 |  |  |
| Total | 2405.730 | 600 |  |  |  |
| Corrected Total | 104.297 | 599 |  |  |  |

1. R Squared = .577 (Adjusted R Squared = .573)
2. Site = Out Station, State = Kogi

Appendix 35: Body weight comparison in Kogi by LGA by sex ( out-station)

**Test of Between- Subjects Effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Type IV Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | 60.847a | 5 | 12.169 | 161.974 | .000 |
| Intercept | 2108.625 | 1 | 2108.625 | 28065.820 | .000 |
| LGA | .427 | 4 | .107 | 1.420 | .226 |
| Sex | 60.420 | 1 | 60.420 | 804.194 | .000 |
| Error | 44.628 | 594 | .075 |  |  |
| Total | 2214.100 | 600 |  |  |  |
| Corrected Total | 105.475 | 599 |  |  |  |

1. R Squared = .577 (Adjusted R Squared = .573)
2. Site = Out Station, State = Kogi

Appendix 36: Body weight comparison in Nasarawa by LGA by sex (out-station)

**Test of Between- Subjects Effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Type IV Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | 37.125a | 5 | 7.425 | 80.261 | .000 |
| Intercept | 1963.814 | 1 | 1963.812 | 21227.754 | .000 |
| LGA | .717 | 4 | .179 | 1.936 | .103 |
| Sex | 36.309 | 1 | 36.309 | 393.485 | .000 |
| Error | 52.177 | 564 | .093 |  |  |
| Total | 2044.940 | 570 |  |  |  |
| Corrected Total | 89.203 | 569 |  |  |  |

1. R Squared = .416 (Adjusted R Squared = .411)
2. Site = Out Station, State = Nasarawa

Appendix 37: Body weight comparison in Niger by LGA by sex (out-station)

**Test of Between- Subjects Effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Type IV Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | 50.000a | 5 | 10.000 | 157.447 | .000 |
| Intercept | 1970.516 | 1 | 1970.516 | 31025.185 | .000 |
| LGA | .038 | 4 | .010 | .151 | .963 |
| Sex | 49.880 | 1 | 49.880 | 785.353 | .000 |
| Error | 34.615 | 545 | .064 |  |  |
| Total | 2062.720 | 551 |  |  |  |
| Corrected Total | 84.615 | 550 |  |  |  |

1. R squared = .591 (Adjusted R Square =587)
2. Site = Out Station, State = Niger.

Appendix 38: Body weight comparison in Abuja by LGA by sex (out-station)

**Test of Between- Subjects Effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Type IV Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
| Corrected Model | 56.099a | 5 | 11.220 | 140.936 | .000 |
| Intercept | 1969.402 | 1 | 1969.402 | 24738.321 | .000 |
| LGA | .182 | 4 | .046 | .572 | .963 |
| Sex | 55.798 | 1 | 55.798 | 700.901 | .000 |
| Error | 44.183 | 555 | .080 |  |  |
| Total | 2089.930 | 561 |  |  |  |
| Corrected Total | 100.282 | 560 |  |  |  |

1. R squared = .559 (Adjusted R Square =555)
2. Site = Out Station, State = FCT.

Appendix 39: Productivity of Indigenous Chickens by state.

**Tests of between-subjects Effects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source Dependent variable | Type IV sum of squares | df | Mean square | F | Sig. |
| Corrected Clutch  Egg inc  Egg Ha  Ch. Wn  Hatch .ty  Clutch No  AFE  Mortality | 424 3602  5253 .818b  355.900c  2.482d  .050e  .002f  2.912g  .002h | 5  5  5  5  5  5  5  5 | 84.874  1050 764  71 .180  495  .050  .002  2.912  .002 | 9.022  4.964  33. 697  3.157  .134  .002  1.337  .002 | . 003  .000  .000  .004  .715  .964  248  .967 |
| Intercept Clutch  Egg inc  Egg Ha  Ch. Wn  Hatch .ty  Clutch No  AFE  Mortality |  | 1  1  1  1  1  1  1  1 | 786001.577  72564.181  75644.719  3531.831  87466.968  1784003.735  105591.301  814122.380 | 820195.291  56375.192  479026.075  16.6636  231262.330  2207850.220  48475.220  588048.978 | .000  .000  .000  .000  .000  .000  .000  .000 |
| State Clutch | 424 360a | 5 | 84.874 | 9.022 | .003 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Egg inc  Appendix 39 (Contd): Productivity of Indigenous Chickens by state.  Egg Ha  Ch. Wn  Hatch .ty  clutch No  AFE  Mortality | 5253 .818b  355.900c  2.482d  .050  .002  2.912  1401. 232 | 5  5  5  5  5  5  5 | 1050 764  71 .180  495  .050  .002  2.912  56.002 | 4.964  33. 697 3.157 .134 .002 1.337  18.203 | .000  .000  .000  .715  .964  .248  .051 |
| Error Clutch  Egg inc  Egg Ha  Ch. Wn  Hatch .ty  clutch No  AFE  Mortality | 69575.734  673.207  825.888  1110351.478  1978.066  4178.607  11392.264  7240.655 | 5230  5230  5230  5230  5230  5230  5230  5230 | 9.479  129  58  212.304  378  799  2.178  1.384 |  |  |
| Total Clutch  Egg inc  Egg Ha  Ch. Wn  Hatch .ty  Clutch No  AFE  Mortality | 8277199.720  76603.010  79959.080  1113945.869  93460.940  1849738.865  122113.865  858994.650 | 5232  5232  5232  5232  5232  5232  5232  5232 |  |  |  |
| Corrected Total Clutch  Egg inc  Egg Ha  Ch. Wn  Hatch .ty  Clutch No  AFE  Mortality | 49586.664  673.214  825.895  1110374.155  1978.116  4178.607  11395.176  7240.658 | 5231  5231  5231  5231  5231  5231  5231  5231 |  |  |  |

1. R squared = .000 (adjusted R square = .000)
2. R squared = .000 (adjusted R square = .000)
3. R squared = .000 (adjusted R square = .000)
4. R squared = .000 (adjusted R square = .000)

**Post Hoc tests**

**State**

**Homogeneous subsets**

**Clutch size**

**Ryan- Gabriel-Welsch Fa**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Subset | |
| State | N | 1 | 2 |
| Nasarawa  Kogi  Benue  Niger  FCT  Control  Sig. | 390  394  358  388  402  330 | 11.45917  11.24653 11.20894  10.95123  10.84225      .119 | 14.11680 1.000 |

**Eggs Incubated**

**Ryan- Gabriel-Welsch Fa**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Subset | |
| State | N | 1 | 2 |
| Nasarawa  Kogi  Niger  FCT  Benue  Control  Sig. | 390  394  388  402  358  330 | 11.38359  11.17183  10.70196  10.32491  8.71189  .699 | 13.11680 1.000 |

**Eggs Hatched**

**Ryan- Gabriel-Welsch Fa**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Subset | |  |
| State | N | 1 | 2 | 3 |
| Niger  FCT  Kogi  Nasarawa  Benue  Control  Sig. | 388  402  394  390  358  330 | 8.48234 | 11.28159  10.93183  10.43196  10.14691 | 13.11245  1.000 |

**Chicks Weaned**

**Ryan- Gabriel-Welsch Fa**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Subset | |  |
| State | N | 1 | 2 | 3 |
| FCT  Kogi  Nasarawa  Niger  Benue  Control  Sig. | 402  394  390  388  358  330 | 3.91189 | 5.76359  5.29183  5.21196  5.20491 | 9.60234  1.000 |

**Hatchability**

**Ryan- Gabriel-Welsch Fa**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Subset** |  |
| State | N | 1 |
| Nasarawa  FCT  Kogi  Niger  Benue  Control  Sig. | 390  402  394  388  358  330 | 99.12159  98.25823  97.85196  97.48291  97.36189  94.81034 |

**Clutch number**

**Ryan- Gabriel-Welsch Fa**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Subset** |  |
| State | N | 1 |
| Niger  FCT  Kogi  Nasarawa  Benue  Control  Sig. | 388  402  394  390  358  330 | 3.31359  3.23183  3..06196  3.03691  3.00389  3.22346 |

**Age at first egg**

**Ryan- Gabriel-Welsch Fa**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Subset** |  |
| State | N | 1 |
| Niger  FCT  Kogi  Nasarawa  Benue  Control  Sig. | 388  402  394  390  358  330 | 156.13159  151.32183  150.32196  146.33691  143.42189  141.45752 |

**Mortality**

**Ryan- Gabriel-Welsch Fa**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Subset | |  |
| State | N | 1 | 2 | 3 |
| Nasarawa  Kogi  Niger  Benue  FCT  Control  Sig. | 390  394  388  358  402  330 | 6.07359  5.64183 5.23196 4.57291  4.38589 | 3.51243  5.000 |  |