

**COMPARATIVE STUDY OF GROWTH AND SEASONAL INFLUENCE ON SOME
REPRODUCTIVE HORMONES AND EGG PRODUCTION IN TWO STRAINS OF
GUINEA FOWL (*Numida meleagris*)**

BY

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NOVEMBER, 2017

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BY

Mas'ud ABUBAKAR, PGD ANIMAL PRODUCTION (ABU, ZARIA) 2009

P14AGAN8012

**A DESSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES,
AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE AWARD OF A MASTER DEGREE IN ANIMAL SCIENCE**

**DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE,
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ZARIA, NIGERIA**

NOVEMBER, 2017

DECLARATION

I declare that the research work titled “**Comparative Study of Growth and Seasonal Influence on some Reproductive Hormones and Egg Production in Two Strains of Guinea Fowl (*Numida meleagris*)**” was carried out by me at the Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Kaduna State of Nigeria under the supervision of Dr. M. Kabir and Professor I. A. Adeyinka. The information obtained from literature has been duly acknowledged in the text and the list of references provided. No part of this Dissertation has been previously presented for another degree or diploma at any university.

Name of student

Signature

Date

CERTIFICATION

This Dissertation titled “**COMPARATIVE STUDY OF GROWTH AND SEASONAL INFLUENCES ON SOME REPRODUCTIVE HORMONES AND EGG PRODUCTION IN TWO STRAINS OF GUINEA FOWL (*Numida meleagris*)**” by **MAS’UD ABUBAKAR** meets the regulations governing the award of the degree of Masters of Science in Animal Science of the Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge.

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DEDICATION

This dissertation is dedicated to my mother Hajiya Amina and to my father Alhaji Abubakar.

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty Allah for granting me the ability to complete this work. May His peace and blessings be upon his prophet Muhammad (SAW).

My sincere gratitude is hereby expressed to my supervisors, Dr. M. Kabir and Professor I. A. Adeyinka for their guidance, cooperation and unquantifiable moral and academic assistance. I am most grateful to you.

My thanks also go to Dr. S. B. Abdu, Dr. R. Hassan, Prof. D. Zaharaddeen, Dr. I. I. Adedibu, Dr. I. Tunji, Dr. M. Abdulrashid, Prof. S. Duru, my academic grandfathers Prof. G. N. Akpa and Prof. B. I. Nwagu.

To my parents, Hajiya M. Amina and Alhaji A. Abubakar for their support and prayers. My deep appreciation goes to my family for their invaluable assistance in the completion of this work. Others worthy to mention here for their commendable efforts and suggestions are Abbaya Hassan, Aisha M. Aliyu, Musa Umar, Mallam M. Yunusa of the Veterinary Department and Mallam M. Muhammad of the Chemical Pathology Laboratory, Teaching Hospital, Shika, Zaria.

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ABSTRACT

A comparative study of growth (Body weight and linear body measurements; Neck length, Body length, Thigh length, Shank length and Breast width) and seasonal influence on some reproductive hormones (luteinizing hormone (LH), progesterone (P₄) and estradiol (E₂) and egg production in two strains of guinea fowl (Belgie and Pearl) was conducted at the Poultry Unit, Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Kaduna State. Body weight and linear body measurements were taken biweekly from 16 weeks to 28 weeks of age. The year was classified into four seasons; late dry (January, February and March); early rain (April, May and June); late rain (July, August and September) and early dry (October, November and December). Level of reproductive hormones and egg production were assessed in each season. There was a significant (P<0.05) strain effect on body weight throughout the experimental period, mean body weight ranged from 488.13 ± 8.84 to 1057 ± 9.3g and 309.35 ± 7.4 to 782.86 ± 7.16g in Belgie and Pearl strains, respectively. There was also significant (P<0.05) difference in linear body measurements at different ages with Belgie having the highest value in all the parameters measured. Season had significant (P<0.05) effect on hormonal level with highest figure obtained in the late rainy season. Means for the hormonal assay in the late rainy season were LH-4.670 ± 0.25, P₄- 1.390 ± 0.11, E₂- 2.000 ± 0.2 and LH- 5.060 ± 0.2, P₄- 1.970 ± 0.08 and E₂- 1.860 ± 0.19 in Belgie and Pearl, respectively. There was no egg production in season one; late dry. Total egg produced during the late rainy season was significantly (P<0.05) higher than what was produced in the other seasons in the two strains. Correlation coefficients for body weight and linear body measurements were positive and high in Belgie; BDL 0.804, BRW 0.955, NKL 0.765, THL 0.857, SHL 0.826 while in Pearl, they were positive and high in breast width 0.903, thigh length 0.884 and neck length 0.892 but low in back length 0.268 and shank length 0.252.

Correlation coefficients for season and hormones were positive and high during the late rainy season; LH 0.546, P₄ 0.771, E₂ 0.828 while that of season and egg number was positive and low. Belgie strain can be improved upon for better growth traits while Pearl for better egg production trait.

CHAPTER ONE

1.0 INTRODUCTION

Malnutrition has been a persistent problem in Africa especially Nigeria. The most important area of deficiency is in the intake of animal proteins. Guinea fowl (*Numida meleagris*) meat and egg contribute immensely to the alleviation of this animal protein deficiency with demand being higher than supply and can be a tool for poverty reduction (Koney, 2004). Attractive plumage and value as a table bird with game-type flavor and higher meat to bone ratio of guinea fowl has led to its worldwide acceptance (Embury, 2001). They are widely consumed by a large number of Nigerians because of the meat and egg which possess distinct flavor and taste (Ayeni and Ayanda; 1982).

Guinea fowl production is associated with small holder farmers in Africa and is described as "poor man's pheasant" (Smith, 2000). It has ambiguous distribution in Africa where it has distinct popularity among small holder farmers (Nwagu and Alawa 1995). This specie of poultry is kept for various purposes depending on the society. Like chicken, guinea fowls are a source of protein (Embury, 2001). Other advantages of rearing guinea fowl include; low production cost, greater capacity to utilize green feeds, control of ticks and other pests and better ability to protect itself against predators and fewer requirements for labour and management (Sayila, 2009). However, egg production is seasonal in guinea fowls (Ogwuegbu *et al.*, 1988). Sonaiya and Swan (2004) also reported that guinea fowls are seasonal breeders, laying eggs only during rainy season, under free range conditions. This is because successful poultry species instinctively lay and incubate their eggs at a time of the year when newly hatched chicks will have a better supply of high protein and energy food provided by the environment. Saina *et al.* (2005) reported 5±1 months breeding season in Zimbabwe, Southern Africa.

The seasonality of production has been recognized as one of the major problems that may hinder large scale commercial guinea fowl production. Factors responsible for this seasonality are however not yet clearly known. Progesterone, estradiol and luteinizing hormone are the most important steroid hormones affecting reproduction in livestock and poultry and have been reported to be positively related to egg production in turkeys (Mashaly *et al.*, 1979). Tanabe *et al.* (1981) reported a positive correlation between circulatory levels of progesterone and estradiol in egg production in laying hens in a pure-line. The preovulatory rise in plasma progesterone and estradiol precede and stimulate the rise in luteinizing hormone and there is a positive feedback reaction between progesterone, estradiol and luteinizing hormone that induces ovulation (Kanoth and Sharp, 1998). Adeyinka *et al.* (2007) reported a positive correlation between circulatory level of progesterone and egg production in guinea fowls *Numida meleagris galeata*.

The live body weight of any animal is an important variable that determines market value of that animal. There is variation in growth performance of different strains of guinea fowl (Fajemalehin 2010). The exact time at which the animal is ready for slaughter can be assessed on the basis of its body weight and general development (Akanno and Ibe, 2006). Age is a major determinant of growth and physiological development in livestock (Assan, 2013).

Linear body measurement helps in comparison of growth in different parts of the body. It has been severally used to characterize strains, evaluate carcass yield, sex performance and predict live weight gain in livestock (Oke *et al.*, 2014). Linear body measurements have a recurring interest to livestock production either to supplement body weight as a measure of productivity or as predictors of some less visible characteristics (Sapriyantono *et al.*, 2012).

Body weight has direct relation to the production and profitability of any livestock enterprise. Body weight measurement is used the most to evaluate body development in livestock and

poultry production (De Brito Ferreira *et al.*, 2000), but it is not easily measured in the field. Several studies have shown that body weight has a direct relationship with morphometric characteristics and carcass traits in poultry (Ogah, 2011).

The strong relationship existing between body weight and linear body measurements may be useful as selection criteria, since positive correlations of traits suggest that they are under the same gene action (pleiotropy) (Kabir *et al.*, 2006; Aziz and Al-Hur, 2013). This study was undertaken to compare the body weight and morphometric traits and seasonal influence on some reproductive hormones and egg production in two strains of guinea fowl in a humid rainforest zone.

1.1 Justification

It has well been identified that very little is done in terms of scientific research into the production, management and improvement of the indigenous guinea fowls as compared to domestic chicken (Magaga and Haule, 1994).

Studies investigating the difference existing in growth performance and egg production among different strains of guinea fowls, have focused on nutrition (Jones *et al.* 2010, Nahashon *et al.* 2007) and on the effect of housing system (Yamak *et al.* 2016).

Growth performance in guinea fowls may also be affected by genetic effect while egg production apart from genetic effect may be affected by season and reproductive hormones availability. Therefore, the present study is aimed at comparing the growth performance and seasonal influence on some reproductive hormones (LH, P₄, E₂) and egg production in two strains of guinea fowls (Belgie and Pearl).

1.2 Objectives of the Study

- i. To compare the growth performance (Body weight and linear body measurements) of Belgie and Pearl strains of guinea fowl.
- ii. To assess the effect of season on some reproductive hormones (progesterone, estradiol and luteinizing hormones) and egg production between the two strains of guinea fowls (Belgie and Pearl).

1.3 Research Hypotheses

Null hypotheses (H_0): There is a significant difference between body weight and linear body measurements in Belgie and Pearl strains of guinea fowl.

Alternative hypotheses (H_a): There is no significant difference between body weight and linear body measurements in Belgie and Pearl strains of guinea fowl.

Null hypotheses (H_0): Season has no significant effect on some reproductive hormones (luteinizing hormone, progesterone and estradiol) and egg production in Belgie and Pearl strains of guinea fowl.

Alternative hypotheses (H_a): Season has significant effect on some reproductive hormones (luteinizing hormone, progesterone and estradiol) and egg production in Belgie and Pearl strains of guinea fowl.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Guinea Fowl Origin, Varieties and Distribution

Guinea fowl (*Numida meleagris*) are indigenous to West Africa, North of the Equatorial forest where there is an estimated population of about 4.7million guinea fowls (FDLPS/RIM, 1991). It got the name ‘Guinea’ because it was believed to have originated from Guinea in West Africa.

Among domestic types which the peasant farmers have long identified and given local names based on their colouration are; Pearl: black plumage splashed with white (Sake), Lavender: ash color (Hurudu), Black: black plumage (Angulu), White: white plumage (Farin Zabi) and Grey breasted: grey or white breast feathering (Hankaka) (Ikani and Dafwang, 2004).

In Nigeria, the most widely distributed guinea fowl is the helmeted guinea fowl *Numida meleagris galeata* (Grey breasted guinea fowl). It inhabits the grass land areas spreading from the derived savanna near the forest zone in the south through the true savanna into the northern guinea savanna vegetation zone (Ayeni, 1979). Akinwumi *et al.* (1979) reported that about 45 million of the helmeted guinea fowl are found as semi domesticated birds in Nigeria.

Ayeni (1979) further reported that the forest dwelling crested guinea fowl (*Guttera edouradi edouradi*) is restricted to the southern Nigeria forest and derived savanna forest edges. Akinwumi *et al.* (1979) and Ayorinde (1983) observed that the Northern most part of Nigeria has the largest population of guinea fowl.

2.2 Guinea Fowl Management Systems

According to Saina *et al.* (2005), guinea fowl management systems in Africa in general are classified into three systems. The classification is based on the flock size, productive inputs and output relations. The basis of the classification is varied, access and availability to the three factors of production such as capital, land and labour play a significant role in the classification. The systems practiced are;

2.2.1 Intensive system

The system is used commercially and involves confining the birds indoors either on battery cages or on deep litter within large controlled environment. Food and water requirements are made available all the time. This system of guinea fowl production is based on specialized strains. Standard managements such as appropriate housing, feeding and disease control program are followed (Ikani and Dafwang, 2004).

2.2.2 Semi-intensive system

The semi-intensive system is characterized by use of minimum inputs with the birds scavenging. Investment in this system does not go beyond acquisition of foundation stock. Usually a handful of grain is given each day. The system includes provision of permanent housing. The birds are provided supplementary feeding and water within the houses. The stocking density of up to 500 birds per acre is kept (Ikani and Dafwang, 2004). Diseases are controlled to enhance productivity. The semi-intensive management system allows the birds to scavenge from the environment as the form of food supply.

2.2.3 Extensive system (free range)

This is the most common and suitable form of management for farmers with a lot of land and field for pasture and is referred to as the free range system (Moreki and Seabo, 2012). This system, the birds find their own food and shelter and therefore are almost kept at no cost to the farmer. In this system, the farmer keeps different species of poultry such as guinea fowls, chickens, ducks and turkeys (Ikani and Dafwang, 2004). The system is mostly carried out by small scale farmers in the rural areas where land is available to roam and feed themselves. Under the extensive system, the birds are exposed to extreme weather conditions which often results to heavy losses through predators, parasite infections and diseases. Improvement in the extensive system is of economic importance as it involves the entire rural population. Modifications which can improve the extensive system include provision of water and health care services.

2.3 Body Weight

Body weight has direct relation to the production and profitability of any livestock enterprise. Body weight measurement is used the most to evaluate body development in livestock and poultry production (De Brito Ferreira *et al.*, 2000).

2.3.1 Influence of age, sex, strain and management system on body weight

2.3.1.1 Age

Kabir and Alexander (2015) reported age as a major determinant of growth (body weight) and physiological development in livestock.

2.3.1.2 *Sex*

Male Animals consume more feed, utilize the feed more efficiently and gain more body weight than females (Benyi *et al.*, 2015).

2.3.1.3 *Strain*

Fajemilehin (2010) reported that there was variation in growth performance (body weight and linear body measurements) among different strains of guinea fowl and recorded mean values of body weight in Pearl, Ash and Black at the age of 16-28 weeks of age as shown in Table 2.1.

Table 2.1 Body weight of Pearl Ash and Black Strains of Guinea owl

Weeks	Pearl	Ash	Black
16	685.26 ± 0.71	650.16 ± 0.49	652.83 ± 0.90
18	730.01 ± 0.70	710.41 ± 0.73	716.26 ± 0.65
20	801.65 ± 0.92	770.17 ± 0.35	774.86 ± 0.46
22	860.03 ± 0.45	836.7 ± 0.71	826.09 ± 0.67
24	901.50 ± 0.87	870.49 ± 0.54	864.20 ± 0.73
28	980.15 ± 0.30	970.43 ± 0.72	980.15 ± 0.70

Fajemelehin (2010)

2.3.1.4 Management system

The difference existing in growth performance among different strains of guinea fowls was as a result of management system (Yamak *et al.*, 2016).

2.3 Linear Body Measurements

2.3.1 Neck length

It is an early maturing trait that enables birds to have good view of their surroundings to detect danger or see predators in advance (Nsoso *et al.*, 2006). Samuel *et al.* (2013) recorded mean values of neck length in Pearl strain as 10.10 ± 0.10 , 11.22 ± 0.06 , 11.48 ± 0.8 , 12.52 ± 0.08 , 13.08 ± 0.06 , 13.65 ± 0.05 and 14.08 ± 0.6 at 16, 18, 20, 22, 24, 26 and 28 weeks of age.

2.3.2 Body length

It is the distance from the base of the neck to the uropygial gland at the base of the tail. Fajemilehin (2010) recorded mean values of body length of 41.68 ± 0.90 , 41.81 ± 1.00 and 41.75 ± 0.89 at 28 weeks in Pearl, Ash and Black.

2.3.3 Thigh length

It was measured from hock joint to the hinge joint. Fajemilehin (2010) recorded mean values of thigh length of 13.89 ± 0.06 , 13.68 ± 0.09 and 13.66 ± 0.08 at 28 weeks in Pearl, Ash and Black strains of guinea fowl.

2.3.4 Shank length

Shank length was measured as the distance between the footpad and the hock joint and is an early maturing trait that is needed to support the whole body frame (Fajemilehin, 2010). Fajemilehin (2010) recorded mean values of shank length of 9.03 ± 0.09 , 8.85 ± 0.09 and 8.93 ± 0.08 in Pearl, Ash and Black strains.

2.3.5 Breast width

Breast development is a good measure of meatiness in poultry (Fajemilehin, 2010). Oke *et al.* (2014) has reported breast width of 18.67 ± 0.18 , 16.40 ± 0.18 and 17.80 ± 0.43 at 28 weeks in Pearl, Ash and Black strains.

2.4 Phenotypic Correlation for Body Weight and Linear Body Measurements

Kabir *et al.* (2006) and Aziz and Al-Hur, (2013) reported positive and high correlations between body weight and linear body measurements in poultry which can be used as selection criterion, since positive correlations of traits suggest that they are under the same gene action (pleiotropism) (Kabir and Alexander, 2015).

2.5 Effect of Season on Egg Production, Fertility and Hatchability

2.5.1 Egg production

Egg production or number is the most useful criterion in the evaluation of the performance of hens (Ayorinde, 1983). Guinea fowl eggs are relished in Nigeria for their distinct flavor and are regarded in some communities as an aphrodisiac (anything that arouses sexual desire). Like those of the domestic fowl, guinea fowl eggs are rounded at one end and pointed at the other, although the eggs are considerably smaller. In other aspects, ranging from shell thickness to internal quality characteristics, the eggs of guinea fowl compare favorably with those of the domestic fowl. The thicker and stronger shell of guinea fowl eggs help to give them an exceptionally long shelf life and ensures fewer breakages when being transported on bad roads.

The report of Oguntuna (1982) has indicated that the guinea fowl hen come into lay at about 25-28 weeks of age and continue to lay for about 8 months producing 150-180 eggs during the first laying period. The second laying period may start 12-14 weeks after the end of the first and may last for 4-5 months producing slightly higher number of eggs than that

produced in the first cycle. Olomu (1983) reported that unselected guinea fowls at NAPRI, Zaria had hen day production of 16.4%, commenced lay in May and terminated in late September. This breeding season incidentally corresponded to the rainy season while the resting or non-breeding season fell into the dry season. It was observed that the peak egg-laying was July (58.99%); egg laying was lowest in September (0.82%) (Oguntuna, 1982). In addition, Offiong (1983) observed that in spite of the improved management, guinea fowl at Vom, laid only during the rainy season. It would therefore seem that the seasonal nature of their production might be genetic. Egg production or egg number cannot be considered as a single entity because it is very closely related to egg weight and body weight, both of which are economically important. Thus, a proper balance between the number of eggs produced and the associated characteristics cannot be ignored.

2.5.2 Fertility

Poor fertility is often a problem in domesticated flocks of guinea fowl. Information on the relative fertilizing capacity of semen from successive ejaculates in a series is not available in the Nigerian guinea fowl. However, good results have been achieved under commercial condition in France by the use of artificial heat for breeders to maintain a temperature of 22°C. For small unimproved flocks kept in captivity, it was found that few eggs laid outside normal breeding season are fertile (Ayorinde, 1983). Also, the first few eggs in a flock are rarely fertile and in many instances the same applied to egg produced at the end of the season.

Guinea fowl hens remain fertile after the withdrawal of cocks for 8-12 days (Stekelener, 1966). The same author found that first fertile eggs were produced in guinea fowl hens 44-88 hours after insemination, either artificially or naturally. Apart from this, the percentage of hens that produce fertile eggs among others depend on the ratio of males to females, which determines whether or not and how soon the hens are mated; previous exposure of the

females to males; time of mating; male integrity; the integrity of the females; the shell quality and individual characteristics of the egg (Orji and Isu, 1983).

Ayorinde and Ayeni (1986) found that fertility was lowest during January to March, and October to December period which correspond to seasons of adverse climatic conditions (hot dry seasons and cold dry seasons respectively). Also, highest fertility and moderate dead in shell were observed during July to September, which is a period of maximum spermatogenic activity in guinea fowls. It appears, therefore, that low temperature, high rainfall and humidity prevailing during the late rainy season probably favour egg fertility while temperature, low rainfall and low humidity in the hot dry season and cold harmattan depress it.

The egg fertility in all the groups studied at New Bussa in Nigeria by Ayorinde and Ayeni (1986) were lower than the 80-85% reported by Trerjjakov and Peljtcer (1954), but during the rains the new Bussa values were similar to the 64.2-76.00% obtained by Leopald and Zironi (1971) and 67.0-77.1% by Roiter (1976) in Italy as well as the 71.54-74.29% reported by Offiong and Abed (1980) in Vom, Jos, Nigeria.

2.5.3 Hatchability

Hatchability is the percentage of fertile eggs which hatch under artificial incubation. It is influenced by many factors such as: age of breeding stock, rate of egg production of the breeder and rations fed, season of the year, size of eggs, character of egg shells, length of holding time after laying and conditions under which eggs hatching are held, temperature, humidity, and other conditions in the incubator, as well as hens that laid the eggs or the males that fertilized them (Tebesi *et al*, 2012).

Hatchability is a serious problem in guinea fowls. Poor hatchability may be caused by long period of egg storage or infertility (Oguntuna, 1982). From lay day, hatchability of guinea

fowl eggs deteriorates by 3.84% per day (Ayorinde, 1986). If there are no cooling facilities, Ogundipe (1976) advised that eggs should be stored in a cool and well ventilated room for not more than 7 days. At 12.7°C, hatchable eggs could be stored for up to 2 weeks.

Ayorinde and Ayeni (1986) reported hatchability of fertile eggs to be highest in the local Pearl crossed with exotic Pearl, guinea and local Pearl crossed with local Pearl stocks. This was observed between July and September (rainy season) and also between April and June (early rainy season). They found that the low temperature and high humidity experienced in the early season resulted in higher percent hatchability and that the guinea fowl has a notoriety in Africa folklore for its inability to lay many hatchable eggs. From the work of Ayorinde and Ayeni (1986) between 54 and 92% of the total eggs set failed to hatch for reasons which possibly include egg infertility, death of embryo before the 28th day and inability of the mature of chicks to come out of the eggs.

Selection, artificial insemination and improved strategies could be employed to improve fertility and improve hatchability. In Nigeria, Ayorinde and Falayi (1986) obtained higher fertility and hatchability in artificially inseminated guinea fowls as opposed to natural mating. Ayorinde and Ayeni (1986) suggested that with increased domestication, selection for layer guinea fowl and improved management practices including application of artificial insemination, hatchability can be improved in guinea fowl.

Adeyinka (2007) observed positive and high correlation in egg production between rainy season and other seasons.

2.6 Endocrine Function in Reproduction

Hormonal events are important in the breeding period (Dennis, 1978; Siversides *et al.*, 1983) and several well known hormones are involved directly or indirectly in the control of egg lay in birds. Estrogen, progesterone, androgen and corticoids have directly stimulated the

synthesis of protein in the oviduct and liver. The bird endocrine system is largely responsible for determining the laying pattern which for hens consists of irregular cycles. Similar hormones as those involved in mammalian reproduction take part in the egg cells growth, maturation and expulsion (Janusz and Zeiba, 1982). In the chicken, the plasma concentration of luteinizing hormone, prolactin has been measured during growth and sexual maturity (Sharp, 1975). Plasma concentration of luteinizing hormone was found to be higher in commercial egg laying type strain than in a broiler type strain (Williams *et al.*, 1969). Evidently, a stimulus for increased luteinizing hormone secretion is provided on one hand by light and on the other hand by the presence of an egg in the oviduct (Dennis, 1978).

In most seasonally breeding photoperiodic mammals and birds, prolactin secretion increases when day length are long (Kanno and Sharp, 1998).

2.6.1 Role of progesterone and estradiol in egg production

Progesterone and estradiol are one of the most important steroid hormones that affect reproduction of birds (Mashaly and Wentworth, 1974). Peterson and Common (1971) and Kappauf and Van Tienhoven (1972) found a peak of progesterone in the laying hen at four to six hours prior to ovulation.

The preovulatory rise of plasma progesterone and estradiol precede and stimulate the rise in luteinizing hormone and there is a positive feedback reaction between progesterone and luteinizing hormone that induces ovulation (Kanno and Sharp, 1998). Tanabe *et al.* (1981) found a positive correlation between circulatory levels of progesterone and estradiol and egg production in laying hens in a pureline. Johnson and Van Teinhoven (1984) found from their study that preovulatory level of progesterone is directly associated with the ovulation of a mature follicle while estrogens and androgens are responsible for the production and

maintenance of the secondary characteristics (Dennis, 1978), in addition to being involved in the maintenance of sexual periodicity internally.

Progesterone and estradiol have been shown to be positively related to egg production in turkeys (Van Teinoven, 1958; Mashaly and Wentworth, 1974; Mashaly *et al.*, 1979). Furthermore, the importance of progesterone in the induction of ovulation has been reported in chickens and turkeys (Mashaly *et al.*, 1976). Adeyinka (2007) observed positive and high correlation coefficients between progesterone and estradiol levels and egg production.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted at the Department of Animal Science Teaching and Research Farm, Ahmadu Bello University, Zaria, Nigeria. The site is geographically situated between latitude 11°11'N and longitude 7° and 38'E at an attitude of 686m above sea level (Ovimaps 2015). Annual rainfall in this area ranges from 1102mm to 1904mm per annum which last from late April or early May to October. The mean temperature fluctuates from 31°C maximum during the dry season to 18°C minimum during the wet season. It is located 22km Northeast of Zaria city and in the northern guinea savannah zone of Nigeria as reported by (Kabir 2010).

3.2 Experimental Birds and Management

A total of sixty (60) sixteen weeks guinea fowls (Belgie and Pearl) thirty of each strain; 6 males and 24 females were used for the study. The parent stock of Belgie were obtained from Maradi, Niger Republic while Pearl from Zaria, Kaduna state.

3.3 Feeding

A grower mash of 16% CP and 2685kcal ME/kg and water were fed to the guinea fowls from sixteen weeks to twenty eight weeks. A layer mash of 17% CP and 2710kcal ME/kg were also given from twenty eight weeks to the end of the study period *ad-libitum* (Teye *et al.*, 2000).

3.4 Data Collection

3.4.1 Body weight and linear body measurements: measurement of individual weight and linear body measurements were carried out every two weeks at 08:00am before feed was

given. Individual body weight was measured with a digital scale of 2000g capacity graduated in grams.

3.4.1.1 Body linear parameters

Body linear parameters were measured using tailors tape rule in centimeter as described by Fayeye *et al.* (2006).

3.4.1.2 Neck length (NL)

The neck being somewhat arched was gently straightened out with hand and measured from the nape to the insertion of the neck into the body.

3.4.1.3 Back length (BL)

Back length is the distance from the base of the neck to the uropygial gland at of the tail.

3.4.1.4 Shank length (SL)

Shank length was measured from the honk joint to the tarso-meta tarsus.

3.4.1.5 Breast width (BrWd)

Breast width was measured across keel from the left armpit to the right armpit.

3.4.1.6 Thigh length (TL)

Thigh length was obtained by measuring from the hock joint to the hinge joint.

3.5 Blood sampling for the Hormones Assay

Year was classified in to four seasons; late dry; January-March, early rain; April-June, late rain; July-September and early dry; October-December. Blood sampling for hormonal assay was collected seasonally.

Ten female guinea fowls per strain were bled once in every season between the hours of 8:00am and 10:00am. A blood sample (3ml) was taken from the wing veins using 5ml syringe and put into specimen bottles which were immediately transported to the chemical

pathology laboratory at Ahmadu Bello University Teaching Hospital, Zaria for assay of the hormones.

Blood samples collected were centrifuged at 2000R per minute for five minutes and serum was then harvested. Serum samples obtained were appropriately stored at -20°C until analysis. For determining luteinizing hormone, progesterone and estradiol concentrations, enzyme linked immunosorbent assay (ELISA) procedure was employed. Luteinizing hormone was measured in milli international unit per milliliter (mIU/ml) while progesterone and estradiol were measured in nanogram/milliliter (ng/ml).

3.6 Egg collection

Eggs were collected immediately after feeding in the morning and in the afternoon within the hours of 12:00pm-1:00pm. The eggs collected were recorded in a daily egg record book which was summarized at every season

3.7 Data Analysis

Least square means for body weight and linear body measurements were obtained through analysis of variance using General Linear Model Procedure of Quick-R package (R core Team, 2015). The data for hormonal assay was subjected to analysis of variance. Significant differences among means were separated using Duncan Multiple Range Test (Duncan, 1955).

The linear model for growth and linear body measurements is

$$Y_{ij} = \mu + a_i + e_{ij}$$

Where:

Y_{ij} = performance of j^{th} bird in i^{th} strain

μ = overall mean

a_i = effect of i^{th} strain ($i = 2$; Belgie and Pearl)

e_{ij} = random error

3.8 Phenotypic Correlations (r_p) between Traits

The phenotypic correlation between two characters is the correlation between their observed values that arise from correlation between genetic and environmental effects affecting the two characters. The phenotypic correlations between pairs of traits considered were determined using equation described by Becker (1984):

$$r_p = \frac{COV_w + COV_s}{\sqrt{(\sigma_{w(x)}^2 + \sigma_{s(x)}^2) + (\sigma_{w(y)}^2 + \sigma_{s(y)}^2)}}$$

$$S.E (r_p) = \frac{COV_{xy}}{\sigma_x \cdot \sigma_y}$$

Where;

COV_w = within sire covariance components.

COV_s = sire covariance components.

$\sigma^2_{w(x)}$; $\sigma^2_{w(y)}$ = within variance component for traits x and y.

$\sigma^2_{s(x)}$; $\sigma^2_{s(y)}$ = sire variance components for traits x and y, respectively.

Fixed Model for Hormonal Assay is;

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \lambda_k + e_{ijkl}$$

Where; α_i = strain ($i = 2$)

β_j = Hormones ($j = 3$)

λ_k = Season ($k = 4$)

CHAPTER FOUR

4.0

RESULTS

Least square means and standard errors for the traits studied were presented in Tables 4.1-4.7. Strain had significant effect ($P < 0.05$) on body weight and linear body measurements. Belgie strain had higher values for all the traits measured and across all ages. The body weight of Belgie strain was higher than that of Pearl by 57.78% and 35.03% with a body weight difference of 178.78g and 274.21g at 16 and 28 weeks of age, respectively. Body length of Belgie strain was longer than that of Pearl by 26.66% and 22.99% with a difference of 6.34cm and 6.71cm at 16 and 28 weeks of age, respectively. Breast width of Belgie strain was longer to that of Pearl by 13.18% and 26.62% with a difference of 1.3cm and 3.12cm at 16 and 28 weeks respectively. Neck length of Belgie strain was longer than that of Pearl by 44.71% and 30.69% with a difference of 4.65cm and 4.34 at 16 and 28 weeks age, respectively. Thigh length of Belgie strain was longer by 25.48% and 18.27% compared to that of Pearl with a difference of 2.54cm and 2.5cm at 16 and 28 weeks of age, respectively. Shank length of Belgie strain was also longer than that of Pearl by 29.50% with a difference of 1.49cm at 16 weeks and by 1.88% with a difference of 0.17cm at 28 weeks of age.

Correlation coefficients for body weight and linear body measurements were positive and high in Belgie; BDL 0.804, BRW 0.955, NKL 0.765, THL 0.857, SHL 0.826 while in Pearl, they were positive and high in breast width 0.903, thigh length 0.884 and neck length 0.892 but low in back length 0.268 and shank length 0.252 as shown in Table 4.8. Correlation coefficients for season and hormones were positive and high in season 3 (late rain); LH 0.546, P₄ 0.771, E₂ 0.828 while that of season and egg number was positive and low. Table 4.9 showed Least Square Means for hormonal assay and egg production between the two strains with season three having the highest hormonal level and egg production of 1552 and

1675 in Belgie and Pearl, respectively. Table 4.10 showed least square means for egg production in Belgie and Pearl strains of guinea fowl with means of 447.750 and 524.750 in Belgie and Pearl strains respectively. Correlation coefficients between hormonal level and season were positive and high in season three (late rain) as presented in Table 4.11 while those of season and egg production was positive and low in the two strains as presented in Table 4.12.

Table 4.1: Least Square Means (\pm SE) for Body Weight (g) and Linear Body Measurements (cm) in Belgie and Pearl Strains of Guinea Fowl at 16 Weeks of Age

Traits	Strain		CV	
	Belgie	Pearl	Belgie	Pearl
Body weight	488.13 \pm 8.48 ^a	309.35 \pm 7.46 ^b	9.51	13.21
Body length	30.12 \pm 0.22 ^a	23.78 \pm 0.18 ^b	4.08	4.23
Breast width	11.25 \pm 0.16 ^a	9.94 \pm 0.09 ^b	8.08	5.34
Neck length	15.05 \pm 0.17 ^a	10.40 \pm 0.10 ^b	6.37	5.27
Thigh length	12.51 \pm 0.11 ^a	9.97 \pm 0.09 ^b	4.97	5.09
Shank length	6.54 \pm 0.11 ^a	5.05 \pm 0.04 ^b	9.07	4.76

SE = Standard error, CV = Coefficient of variation

Means with the same letters are not significantly different

Table 4.2: Least Square Means (\pm SE) for Body Weight (g) and Linear Body Measurements (cm) in Belgie and Pearl Strains of Guinea Fowl at 18 Weeks of Age

Traits	Strain		CV	
	Belgie	Pearl	Belgie	Pearl
Body weight	624.36 \pm 9.10 ^a	529.88 \pm 8.84 ^b	7.71	8.83
Body length	32.76 \pm 0.23 ^a	24.86 \pm 0.21 ^b	3.73	4.39
Breast width	12.37 \pm 0.14 ^a	11.04 \pm 0.08 ^b	6.13	5.18
Neck length	16.76 \pm 0.18 ^a	11.42 \pm 0.08 ^b	5.59	3.72
Thigh length	14.12 \pm 0.12 ^a	11.03 \pm 0.09 ^b	4.61	4.49
Shank length	7.55 \pm 0.10 ^a	6.09 \pm 0.05 ^b	7.37	4.49

SE = Standard error, CV = Coefficient of variation

Means with the same letters are not significantly different

Table 4.3: Least Square Means (\pm SE) for Body Weight (g) and Linear Body Measurements (cm) in Belgie and Pearl Strains of Guinea Fowl at 20 Weeks of Age

Traits	Strain		CV	
	Belgie	Pearl	Belgie	Pearl
Body weight	711.38 \pm 9.69 ^a	584.28 \pm 8.53 ^b	7.20	7.73
Body length	33.99 \pm 0.19 ^a	25.97 \pm 0.21 ^b	3.04	4.31
Breast width	14.13 \pm 0.10 ^a	12.39 \pm 0.16 ^b	3.75	6.91
Neck length	17.68 \pm 0.16 ^a	12.48 \pm 0.08 ^b	4.79	3.41
Thigh length	14.87 \pm 0.15 ^a	11.98 \pm 0.08 ^b	5.28	3.68
Shank length	8.62 \pm 0.08 ^a	7.14 \pm 0.04 ^b	4.92	3.39

SE = Standard error, CV = Coefficient of variation

Means with the same letters are not significantly different

Table 4.4: Least Square Means (\pm SE) for Body Weight (g) and Linear Body Measurements (cm) in Belgie and Pearl Strains of Guinea Fowl at 22 Weeks of Age

Traits	Strain		CV	
	Belgie	Pearl	Belgie	Pearl
Body weight	789.12 \pm 9.98 ^a	632.82 \pm 7.53 ^b	6.69	6.29
Body length	34.68 \pm 0.22 ^a	13.17 \pm 0.06 ^b	3.31	2.53
Breast width	14.86 \pm 0.09 ^a	14.24 \pm 0.05 ^b	3.14	1.90
Neck length	17.98 \pm 0.17 ^a	13.71 \pm 0.08 ^b	5.09	3.11
Thigh length	15.34 \pm 0.14 ^a	13.17 \pm 0.06 ^b	4.79	2.53
Shank length	9.12 \pm 0.09 ^a	8.18 \pm 0.04 ^b	5.16	2.87

SE = Standard error, CV = Coefficient of variation

Means with the same letters are not significantly different

Table 4.5: Least Square Means (\pm SE) for Body Weight (g) and Linear Body Measurements (cm) in Belgie and Pearl Strains of Guinea Fowl at 24 Weeks of Age

Traits	Strain		CV	
	Belgie	Pearl	Belgie	Pearl
Body weight	877.20 \pm 9.34 ^a	685.75 \pm 7.599 ^b	5.63	6.17
Body length	35.17 \pm 0.19 ^a	29.04 \pm 0.14 ^b	2.98	2.54
Breast width	16.37 \pm 0.09 ^a	14.81 \pm 0.05 ^b	2.83	1.82
Neck length	18.12 \pm 0.15 ^a	14.09 \pm 0.6 ^b	4.52	2.42
Thigh length	15.75 \pm 0.11 ^a	13.72 \pm 0.08 ^b	3.98	3.05
Shank length	9.16 \pm 0.08 ^a	8.90 \pm 0.05 ^b	4.59	2.94

SE = Standard error, CV = Coefficient of variation

Means with the same letters are not significantly different

Table 4.6: Least Square Means (\pm SE) for Body Weight (g) and Linear Body Measurements (cm) in Belgie and Pearl Strains of Guinea Fowl at 26 Weeks of Age

Traits	Strain		CV	
	Belgie	Pearl	Belgie	Pearl
Body weight	970.49 \pm 9.40 ^a	732.49 \pm 7.77 ^b	5.13	5.61
Body length	35.97 \pm 0.16 ^a	29.14 \pm 0.14 ^b	2.37	2.57
Breast width	17.03 \pm 0.09 ^a	14.96 \pm 0.07 ^b	2.99	2.55
Neck length	18.41 \pm 0.11 ^a	14.16 \pm 0.5 ^b	3.16	2.01
Thigh length	16.04 \pm 0.10 ^a	13.81 \pm 0.07 ^b	3.34	2.72
Shank length	9.15 \pm 0.08 ^a	11.94 \pm 2.96 ^b	4.65	5.2

SE = Standard error, CV = Coefficient of variation

Means with the same letters are not significantly different

Table 4.7: Least Square Means (\pm SE) for Body Weight (g) and Linear Body Measurements (cm) in Belgie and Pearl Strains of Guinea Fowl at 28 Weeks of Age

Traits	Strain		CV	
	Belgie	Pearl	Belgie	Pearl
Body weight	1057.07 \pm 9.3 ^a	782.86 \pm 7.16 ^b	4.64	4.84
Body length	35.90 \pm 0.13 ^a	29.19 \pm 0.13 ^b	1.99	2.47
Breast width	18.25 \pm 0.06 ^a	15.13 \pm 0.09 ^b	1.63	3.39
Neck length	18.48 \pm 0.09 ^a	14.14 \pm 0.09 ^b	2.80	3.39
Thigh length	16.38 \pm 0.09 ^a	13.85 \pm 0.07 ^b	2.94	2.64
Shank length	9.19 \pm 0.07 ^a	9.02 \pm 0.04 ^b	4.13	2.26

SE = Standard error, CV = Coefficient of variation

Means with the same letters are not significantly different

Table 4.8: Correlation Coefficient for Growth Traits in Belgie (Above Diagonal) and Pearl (Below Diagonal) Strains of Guinea Fowl

Traits	BWT	BDL	BRW	NKL	THL	SHL
BWT		0.804**	0.955**	0.765**	0.857**	0.826**
BDL	0.268*		0.834**	0.855**	0.839**	0.811**
BRW	0.903**	0.178*		0.764**	0.855**	0.834**
NKL	0.892**	0.167*	0.938**		0.782**	0.818**
THL	0.884**	0.217*	0.935**	0.938**		0.808**
SHL	0.252*	0.107*	0.307*	0.280*	0.282*	

BWT = Body weight, BDL = Body length, BRW = Breast width, NKL = Neck length, THL = Thigh length, SHL = Shank length, *(P<0.05); **(P<0.05).

Table 4.9: Least Square Means (\pm SE) for Hormones and Season on Belgie and Pearl Strains of Guinea Fowl

Season	Strain	Trait	Mean (\pm SE)	Egg production
1	Belgie	LH	0.280 \pm 0.042 ^d	0
		P ₄	0.155 \pm 0.022 ^c	
		E2	0.310 \pm 0.082 ^c	
	Pearl	LH	0.428 \pm 0.064 ^d	
		P ₄	0.220 \pm 0.029 ^d	
		E2	0.210 \pm 0.031 ^c	
2	Belgie	LH	1.700 \pm 0.172 ^c	221
		P ₄	0.520 \pm 0.076 ^b	
		E2	1.060 \pm 0.127 ^b	
	Pearl	LH	2.080 \pm 0.36 ^c	376
		P ₄	0.540 \pm 0.040 ^c	
		E2	0.750 \pm 0.101 ^b	
3	Belgie	LH	4.670 \pm 0.255 ^a	1552
		P ₄	1.390 \pm 0.116 ^a	
		E2	2.000 \pm 0.209 ^a	
	Pearl	LH	5.060 \pm 0.213 ^a	1675
		P ₄	1.970 \pm 0.085 ^a	
		E2	1.860 \pm 0.194 ^a	
4	Belgie	LH	2.206 \pm 0.120 ^b	18
		P ₄	0.480 \pm 0.126 ^b	
		E2	1.390 \pm 0.244 ^b	
	Pearl	LH	3.200 \pm 0.258 ^b	48
		P ₄	1.100 \pm 0.146 ^b	
		E2	1.110 \pm 0.179 ^b	

LH = Luteinizing hormone, P₄ = Progesterone, E2 = Estradiol. Season 1 = Late dry, Season 2 = Early rain, Season 3 = Late rain, Season 4 = Early dry. SE= Standard error. Means with the same letters are not significantly different

Table 4.10: Least Square Means (\pm SE) for Egg Production in Belgie and Pearl Strains of Guinea Fowl

Strain	Mean (\pm SE) egg number
Belgie	447.750 \pm 371.47
Pearl	524.750 \pm 392.41

SE = Standard error

Table 4.11: Correlation Coefficients for Seasons and Hormones

Season		Season	LH
1	Season	-	
	LH	-0.098 ^{ns}	-
	Season		P ₄
	P ₄	0.020 ^{ns}	-
	Season		E2
2	E2	-	
	Season	0.054 ^{ns}	-
	Season		LH
	LH	-	
	LH	0.546 ^{**}	-
3	Season		P ₄
	P ₄	0.178 [*]	-
	Season		E2
	E2	-	
	E2	0.347 [*]	-
4	Season		LH
	LH	-	
	Season		P ₄
	P ₄	0.771 ^{**}	-
	Season		E2
5	E2	-	
	Season	0.828 ^{**}	-
	Season		LH
	LH	-	
	LH	0.024 ^{ns}	-
6	Season		P ₄
	P ₄	0.654 ^{**}	-
	Season		E2
	E2	-	
	E2	0.099 ^{ns}	-

LH=Luteinizing hormone, P₄=Progesterone, E2=Estradiol. Season 1=Late dry, Season 2=Early rain, Season 3=Late rain, Season 4=Early dry. *(P<0.05); **(P<0.05), ns = non significant.

Table 4.12: Correlation Coefficients for Season and Number of Eggs, Strain 1 (Above Diagonal) and Strain 2 (Below Diagonal)

	Number of eggs	Season
Number of eggs	-	0.240
Season	0.237	-

CHAPTER FIVE

5.0

DISCUSSIONS

5.1 Least Square Means (\pm Standard Error) for Body Weight and Linear Body Measurements

Body weight and linear body measurements in the two strains were significantly ($P < 0.05$) different in all the age group examined. Fajemilehin (2010) reported significant difference in the growth performance of different strains of guinea fowls. The values for mean body weight of Belgie were; 488.13 ± 8.48 , 624.36 ± 9.10 , 711.38 ± 9.69 , 789.12 ± 9.98 , 877.20 ± 9.34 , 970.49 ± 9.40 and 1057.07 ± 9.3 while those of Pearl were; 309.35 ± 7.4 , 529.88 ± 8.84 , 584.28 ± 8.53 , 632.82 ± 7.53 , 685.799 ± 7.99 , 732.49 ± 7.77 and 782.86 ± 7.16 both at 16,18,20,22,24,26 and 28 weeks of age, respectively.

The result for growth traits showed increase in all body measurements in each strain as growth advances. This is in agreement with the result of Assan (2013) that stated that age is a major determinant of growth and physiological development.

The result for body weight and linear body measurements revealed that Belgie strain was superior to Pearl. This could be attributed to genetic effect.

5.2 Phenotypic Correlation for Body Weight and Linear Body Measurements

Correlation coefficients for body weight and linear body measurements was positive and high in Belgie while in Pearl, it was positive and high in Breast width, Thigh length and Neck length but positive and low in Back length and Shank length (table 4.8). The high estimates in correlation in this study were comparable to those reported by earlier workers (Kabir *et al.*, 2006 and Aziz and Al-Hur, 2013). The strong relationship existing between body weight and

body measurements may be useful as selection criterion, since positive correlations of traits suggest that they are under the same gene action (pleiotropy).

The phenotypic correlation between body weight and linear body measurements reported in this study are in agreement with the findings of Ogah (2013) who reported medium to high phenotypic correlation coefficients in body weight and linear body measurements in indigenous guinea fowls.

5.3 Least Square Means (\pm Standard Error) for Hormonal Assay Based on Season in Belgie and Pearl Strains of Guinea Fowls

The hormones assayed were luteinizing hormone, progesterone and estradiol. The year was classified into four (4) seasons; late dry (January-March), early rain (April-June), late rain (July-September) and early dry (October-December). The least square means for luteinizing hormone in Belgie were; 0.280 ± 0.042 , 1.700 ± 0.172 , 4.670 ± 0.255 and 2.200 ± 0.120 , progesterone; 0.155 ± 6.022 , 0.520 ± 0.076 , 1.390 ± 0.116 and 0.460 ± 0.126 and estradiol; 0.310 ± 0.082 , 1.060 ± 0.127 , 2.000 ± 0.209 and 1.390 ± 0.244 in season 1, 2, 3 and 4 respectively. The least square means for luteinizing hormones in Pearl strain were; 0.428 ± 0.064 , 2.080 ± 0.362 , 5.060 ± 0.213 and 3.200 ± 0.258 , progesterone, 0.220 ± 0.029 , 0.540 ± 0.040 , 1.970 ± 0.085 and 1.100 ± 0.146 and estradiol; 0.210 ± 0.031 , 0.750 ± 0.101 , 1.860 ± 0.194 and 1.110 ± 0.179 in season 1, 2, 3 and 4 respectively. There was significant difference ($P < 0.05$) in all the hormones except for progesterone and estradiol in Belgie strain in season two (early rain) and four (early dry) and estradiol in season two (early rain) and four (early dry) in Pearl strain. This is in agreement with the results of Tanabe *et al.* (1981) and Itoh *et al.* (1988) who revealed seasonal patterns of plasma concentrations of sex hormones in a variety of avian species such as chicken and guinea fowls.

Plasma concentration of estradiol and progesterone started to increase at the onset of laying (early rain) and reached maximum level in coincidence with highest egg production (late rain) (Tanabe, 1981).

5.4 Correlation Coefficients of Seasons and Hormones

Correlation coefficients for season and hormonal assay were positive and high in season 3 (late rain) and positive and low in the remaining seasons. There was negative and low correlation coefficient between estradiol and progesterone in season 1 (late dry) while progesterone and luteinizing hormone showed positive and high correlation coefficient in season 4 (early dry). Positive and high correlation coefficient obtained in season 3 (late rain) in agreement with the report of Adeyinka *et al.* (2007) who reported positive and high correlation coefficient of reproductive hormones (progesterone) and egg production in the late rainy season in guinea fowls (*numida meleagris galeata*).

5.5 Correlation Coefficients of Season and Egg Number

There were positive, but low correlation coefficients between season and egg number in both strains (Belgie and Pearl). The egg number obtained in this study was significantly higher ($P < 0.05$) in the late rainy season. This was in line with previous reports of collecting highest egg number in guinea fowls during late rainy season (Adeyinka *et al.* 2007; Jesuyon and Salako, 2013). Season 2 (early rain) and 4 (early dry) shared similar characteristics of low egg production and this was in agreement with the submission of Adeyinka *et al.* (2007) who reported low egg production in the early rain and early dry season. There was no significant difference ($P > 0.05$) in egg number between early rain and early dry seasons in the study of effect of season on egg production.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

A study was conducted using two strains of guinea fowl (Belgie and Pearl) at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Science, Ahmadu Bello University, Zaria, Kaduna State, Nigeria. The aim was to compare the growth of the two strains, seasonal influence on some reproductive hormones and egg production. Year was classified into three; late dry, early rain, late rain and early dry. Level of reproductive hormones and egg production were assessed in each season. There was a significant ($P < 0.05$) difference on linear body measurements at different ages with having the highest value in all the parameters measured. Season had significant ($P < 0.05$) effect on hormonal level with highest figures obtained in the late rainy season. Correlation coefficients for season and hormonal assay were positive and high in season 3 (late rain) while those of season and egg number were positive and low.

6.2 Conclusions

Correlation coefficients for body weight and linear body measurements were positive and high in Belgie while in Pearl they were positive and high in breast width, thigh length and length but low in back length and shank length. Correlation coefficients for seasons and hormonal assay were positive and high in season three (late rain) while that of season and egg number was positive and low. strain can be improved upon for better growth traits while Pearl for better egg production. Finally, the results of this study revealed that levels of hormones observed were good estimators of egg production in Belgie and Pearl strains of guinea fowls.

6.3 Recommendations

- It is recommended that when selecting for growth traits, Belgie strain should be used while Pearl strain may be selected for egg production.
- Cross breeding between the two strains to achieve strains complementarity is recommended.
- Since it was revealed that egg production was associated with circulatory level these hormones, a gene responsible for secreting the hormones should be identified for transgenic development.

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