EFFECTS OF SUNLIGHT INTENSITY ON CHICKEN EGG PRODUCTION, SAMARU, ZARIA, NIGERIA

BY

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DEPARTMENT OF GEOGRAPHY,
FACULTY OF SCIENCE,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA.

DECEMBER, 2015

DECLARATION

I declare that this dissertation entitled "Effect of Sunlight Intensity on Chicken Egg Production in Samaru, Zaria, Nigeria" has been conducted by me in the Department of Geography under the supervision of Dr I.A. Abdulhamid and Prof. S. Duru.

The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at any institution.

Hadiza Ahmed SHEHU	__________________	December, 2015
Name of Student	Signature	Date

CERTIFICATION

The thesis entitled "Effects of Sunlight Intensity on Chicken Egg Production in Samaru, Zaria, Nigeria" by Hadiza Ahmad SHEHU, meets the regulations governing the award of the degree in Masters of Science in Geography of the Ahmadu Bello University, and it is approved for its contribution to knowledge and literacy presentation.

Dr.I. A. Abdulhamid ____________________
Chairman, Supervisory Committee ____________________ Sign/Date

Prof. S. Duru ____________________
Member, Supervisory Committee ____________________ Sign/Date

Dr. I. J. Musa ____________________
Head of Department ____________________ Sign/Date

Prof. K. Bala ____________________
Dean, School of Postgraduate Studies ____________________ Sign/Date

DEDICATION

This study is dedicated to the living memory of my late father. May his soul rest in perfect peace, amen

ACKNOWLEDGEMENT

Thanks be to Allah, the Merciful and the Compassionate. I would like to express my sincere gratitude and appreciation to my supervisors Dr I.A. Abdulhamid and Prof S Duru for their inspiration, guidance and perseverance in seeing me to a successful accomplishment of this programme. My appreciation also goes to Dr Binta Abdul of Faculty of Education A.B.U, Zaria who assisted in this study. I would like to use this medium to thank Arc A.S. Salisu (my husband) who also assisted in this study. I will also like to appreciate the efforts of my colleagues such as Abdulkarim Garba and Chafa Mungwa.

I also wish to thank my examiners and anyone who took time to read this work. I hope they find it interesting and worthy of the award.

Finally, I would like to thank my family and friends for their support and understanding throughout the period of this study.

ABSTRACT

An empirical analysis of the Effects of variations in sunlight intensity and chicken egg production was carried out in Samaru, Zaria in Nigeria. The aim of study was achieved by determining the effect of variations in sunlight intensity on the number of eggs, weight and amount of cracked eggs produced. It was carried out using data record on daily illumination obtained from three experimental units in a deep litter animal husbandry with sunlight intensity of low ranging 5 to < 20 lux, moderate ranging 20 to < 200 lux and high ranging 200 lux above. Data on daily record of eggs over a period of 20 weeks were collected and analyzed through a random selection of 60 laying hens of 35 weeks old. While data on poultry feed intake as well as mortality were collected.The results of the analysis using both descriptive and inferential statistics such as mean, multiple analysis of variance showed that variations in sunlight intensity had superiority over the low illumunance resulting in more eggs being laid in high illuminace. There was also relationship between sunlight intensity and number of eggs and weight of eggs produced when subjected to higher illuminance with no significance in the amount of cracked eggs produced. In order to improve poultry productivity in Samaru based on the findings in this research, it is recommended that, there is need for poultry farmers to increase the minimum illuminance to 200 lux and above. Poultry farmers need to establish appropriate housing and sanitation practices for continuous penetration of light. For existing husbandries, there is also need to improve the light intensity by adjusting the 0.9m to less than 0.3m wall with wire mesh not less than 2m height.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Poultry are birds such as domestic fowl, turkey and goose which are reared for useful purposes (Demeke, 2004). They are farmed in large numbers with chickens being the most numerous. Chickens raised for eggs are called layers while chickens raised for meat are called broilers (European Union, 2007). The Food and Agriculture Organization of the United Nations (2011) estimated that in 2002 there were nearly 16 billion chickens in the world, in 2009 the annual chicken population in farms was estimated at 50 billion, with 6 billion raised in the European Union, over 9 billion in the United States and more than 7 billion in China. The global increase in poultry production facilitated the same trend in Nigeria especially on egg production. This plays a significant role in the diet and economy of Nigeria. As a primary source of eggs and meat it also serves as source of income to households alongside other domestic animals. Globally chickens are raised starting with relatively low capital and readily available household labour (Avila, 1985; Foer, 2009).

Egg production is an important aspect of poultry production because of its uses in domestic, industrial sectors and scientific researches. It is a source of human food consumed in various forms because of its peculiar characteristics of being quick, convenient, appetising and easy to prepare. Among other proteins, egg is a source of high quality protein with various essential amino acids, vitamins and readily digestible fat. One egg supplies 11% of the recommended daily protein intake for adults and meets 50% of protein requirement of a child up to 5 years of age. Poultry eggs are low in calories but contain many vitamins. They are used in various food industries, confectionery and for producing cosmetics and vaccines. (Ponapa, 1982; Pennington *et al.* 1983)

World watch Institute (2006) reported that 74 percent of the globe’s poultry meat, and 68 per cent of eggs are produced in ways that are described as 'intensive poultry farming which include indoors husbandry system, commercial furnished cage system and the battery cage system. An alternative to intensive poultry farming is free-range farming using lower stocking densities.

Layers produce an average of one egg per-day in order to maintain constant production. Wide range of environmental conditions affect the performance, health and production of chickens exist, Prominent among these conditions are temperature, relative humidity, sunshine variability, housing system and ventilation vary with locations. The differences also influence the adaptations of species from polar to equatorial ecological regions. The net effect of environmental conditions on poultry farming manifest as indices of health, reproductive efficiency and indeed the general survivability of the animal (Cowan and Michie, 1978; Howlider and Rose, 1987; Starr, 1986)

Comment [b1]: Explain in a sentence what layers are(first paragraph has it)

Light is important in vitamin D metabolism and have profound effects on poultry activities such as production, nest choice, pecking in pullets and laying hens. It is synonymous with luminance and has been in relation to many aspect of welfare in poultry. Vision is the predominant sense in birds, where a large proportion of the total brain size is devoted to eyes and visual cortex (Güntürkün2000). Light provides the main exogenous regulator for the diurnal rhythm of most animals (Nuboer *et al*., 1983; Robbins et al., 1984). Chickens recognise nonspecific’s via visual signals, which requires light (Houser and Huber-Eicher 2004) and also use vision to forage and explore their environment (*Osorio et al*., 2001; Maddocks *et al*., 2001). Naive chicks will avoid conspicuously coloured prey insects and the evolution of such aposematic signals confirms the adaptive value of visual selection of prey items (e.g. Guilford 1990; Osorio *et al*., 2001). Indeed, responding to light may have had an adaptive value for chickens and turkeys through evolution and may still influence the visual perception and behaviour of the birds today. Morris (1994) and CoE (2001) revealed that a source of light bright enough for each bird to be seen clearly and also as working conditions of the staff as well as ensuring adequate inspection of flocks is required.

Studies have shown that the level of performance of poultry does not only depend on inherited capacity but also to a great extent upon the environment (Campbell and Lasley, 1975). Therefore Livestock are confined for the convenience of the owners and Good confinement facilities provide conditions that satisfy all biological necessities for individual animals or groups.

1.2 Statement of Research Problem

For decades, focus on the effects of artificial lighting on different aspects of poultry production, behaviour, physiology and welfare (Manser, 1996; Martrenchar, 1999), animal vision (Prescott *et al*., 2003), and production (Lewis and Morris, 1999) in laying hens has being a global concern.

Several recommendation and regulation on light intensity on poultry exist and varies with region. Despite this, most recommendations were on the grounds of animal welfare and staff working conditions as well as ensuring adequate inspection of the flock and not related to egg production.

Also scientific papers have reviewed the minimum requirement light level for the performance and welfare grounds for pullets and hens and not related to egg production this recommendation on light intensity is only a guide as increase in light could result in an over consumption of feed and may cause Eratic Ovulation and Defective Egg Syndrome (Hyline International, 2011). For instance winter light levels ranging from 200 lux on a cloudy day to as much as 53,000 lx on a clear day have been measured in window-sided pen in the tropics (Chastain *et al*., 1997). This is also a problem with regards to poultry production since the absolute threshold on illumination is yet to be known.

According to King (1998), many people in the livestock industry possess little understanding of how the system works or appreciate how animals interact with the environment, thus compound problems rather than contribute to solutions. These deficiencies, as well as the associated financial losses, have led to an increased interest in developing management techniques that will maximize poultry productivity while minimizing other associated problems such as animal husbandry and management, weather and climate.

Comment [b2]: Which group of people? Remember that pastoralists are the best of livestock keepers! This group of people in the his text must be commercial amateurs(it implies to both)

Numerous studies conducted in various regions have shown that among the other management practices, different regimes of light to which the laying birds are subjected, have significant effect on the weight and size, production percentage and disease control.

There is also a good understanding of how the duration (photoperiod) and wavelength (colour of light) of light affects poultry production, but the knowledge of how light intensity affects egg production is shallow by comparison especially in natural environment (Xin *et al*., 1994; Gates *et al*., 1998). From the sources available, it is not possible to give an absolute threshold for illumination perception in laying hens. This is indeed an area in urgent need of research attention, due to the potential effects on egg production.

None of these studies to the best of the researcher's knowledge has addressed how natural light affect the performance of egg production in the tropics. This is a gap which this study set to fill. This is because Nigeria being a tropical environment has abundance sunlight which makes it uneconomical for poultry farmers to use supplemented light and therefore rely on natural light.

1.3 Research Questions

The study was guided by the following research questions:

I. To what extent does variations in sunlight intensity affect the egg production percentage and number of cracked eggs within the study area?

II. What is the impact of sunlight variations on weight of eggs produced within the study area?

1.4 Objectives of the Study

The broad objective of this study is to evaluate the specific effect of natural light intensity on laying hens in Samaru, Zaria of Kaduna state, Nigeria and the specific objectives are to determine the effect of variations in sunlight intensity on

i. The number of eggs produced.

ii. The weight of eggs produced.

iii. The number of cracked eggs produced.

1.5 Research Hypothesis

The Hypothesis formulated in the study were:

H_0: There is no significant difference between the variations in sunlight intensity on number, weight and number of cracked eggs produced.

H_1: There is significant difference between the variations in sunlight intensity on number, weight and number of cracked eggs produced.

1.6 Scope of the Study

The focus of the study is to assess the effect of sunlight on egg laying hens in Samaru, Zaria, using natural light in a controlled environment within the period of 20 weeks. The study analyzed the variations in sunlight intensity on number, weight and number of eggs produced.

1.7 Justification of the Study

The need to examine the climatic challenges in poultry farming becomes imperative considering the fact that households affirm that it is a tool in poverty alleviation due to the quick turnover and low investment. This implies that if poultry production is improved, it would create opportunity for the development of the poorer segments of the society (Quisumbing *et al*., 1995; Gueye, 1998; Todd, 1998; Permin *et al*., 2000). In order to improve poultry production in Nigeria, the poultry farmers need to establish appropriate housing and climatic conditions.

Generally, few studies on poultry production have been conducted in the study area based on photoperiod, rainfall, temperature and to the researchers' best of knowledge, none of these studies has looked at the direct effect of natural light intensity on egg production in the tropics unlike in the temperate zones, so many studies on artificial source of light have been conducted as sunlight is a major challenge which awakened the interest of this study.

The major focus of this study seeks to provide insight into chicken egg production based on different natural light levels in Samaru, Zaria over the period of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Animal and Environment

The meaning of the term 'animal environment' may vary but is generally defined as any external factor that influences the production response of farm animals and this includes the climatic factors: effective ambient temperature, ventilation, rainfall and relative humidity, photoperiod, light and environmental contaminants, physiological restraints and management system: nutrition, drugs, housing systems and so on (King, 1998).

The study of animal environment was initiated at the University of Missouri where Brody (1948) explained the reason for understanding studies involving the direct effect of climate on livestock. Such questions raised were "how wise is it to import animals from different climatic regions? How do the changed climatic conditions affect the productivity, health and longetivity of the animals? What are the economic reasons a farmer wishes to know before spending his money on farm shelters?" Such knowledge must take for its foundation a study of responses of animals to various environmental factors.

It is evident that there had been early realisation by breeders that animal farm lands have considered the product of their heredity and the environment in which they were reared and this encompasses all non genetic factors that influence the animal's development (Ames and Ray, 1983). The adaptation and acclimatization of the situation is even more complex in livestock production as birds respond to physical, chemical and biological stimuli from their surroundings, because human intervention can influence both genotype and external environment (King, 1998). For instance most captive bird species originated from very hot climate such as the popular Australian specie, adapting to various animal environments (Louise, 1998).

2.2 Economic Significance of eggs

Egg production is an important aspect of poultry production. It has become very important because of its uses in both industrial and scientific sectors. Their production is with significant contribution to human food (Demeke, 2004). Poultry plays an important role in the diet and economy of Nigeria. It is the primary supplier of eggs and meat as a source of income and employment to people compared to other domestic animals (Avila, 1985). They are raised starting with relatively low capital investment and readily available household labour.

Poultry egg contains 74% good source of high protein and it is often used by nutritionist as protein foods. One egg supplies 11% of recommended daily protein intake for adults and 50% of protein requirements of a child up to 5 years of age (Ponapa, 1982).The fat of egg is readily digestible and is made up of both saturated and unsaturated fatty acids. They are used in various food industries, confectionery and for producing cosmetics, leather tanning in tanneries, photo engraving in photographic, vaccines and egg shell waste as a source of calcium in the livestock feed. Among other animal proteins, egg is endowed with various essential amino acids, vitamins and readily digestible fat. This has leaving, binding and clarifying properties essential for good texture in baking and removal of extraneous materials from beverages (Atanda, 1991).

2.3 Effect of Weather and Climate on Egg Production

When considering the birds' microenvironments, temperature and light are two of the major factors (Louise 1998). These factors along with others such as relative humidity, rainfall, air velocity and other climatic elements are selected due to their effect on poultry production.

2.3.1 Effect of Ambient Temperature on Egg Production

Ambient temperature is one of the single most important factors that account for the difference in the performance of birds in different regions of the world. Mc Dowel (1972) observed that temperature is the most important bioclimatic factor affecting the physiological functions of birds which affects the birds' metabolism, and responsible for maximizing growth performance and body heat to maintain normal physiological processes and functions. Charles (1986) revealed that feed intake in laying hen decreased by 1.5gram a day for every degree centigrade rise in temperature and egg production increases by about one egg per bird per year for every degree rise in temperature up to 25 to 30^0C. It has been shown that the chicken is most comfortable, more productive and stress is minimized when the ambient temperature is within thermo neutral zone of below12.8^0 C which is rarely experienced in the tropics (Deaton et al., 1978). It was discovered that laying hens exposed to temperature above 26.7^0 C had significantly lower egg shell breaking, smaller eggs, decreased egg weight, increased water intake and decreased feed intake (Vohra et al 1979; Deaton et al., 1981). The depressive effect of environmental temperature by heat stress is an indication of thermal stress.

2.3.2 Effect of Wind, Rainfall and Relative Humidity

Wind speed has an impact on outbreak of diseases while rainfall and relative humidity affect breathing, feed intake and utilization in birds. High relative humidity above 75 percent will cause a reduction in egg laying and induce the outbreak of diseases in poultry through the creation of conducive breeding environment for disease pathogens. Some of the poultry diseases common in the rainy season are coccidiosis, fowl cholera and ascaris a worm endoparasite disease (Ozbey and Ozcelik, 2004; Elijah and Adedapo, 2006).

2.3.3 Effect of Photoperiodism on Egg Production

Photoperiodism describes the effect of increasing or decreasing day length on such aspects of metabolism as the onset of breeding activity. An increased day length is one of several factors that may bring on egg laying in poultry. Card *et al*. (1976) and Güntürkün (2000) reported that birds are extremely sensitive to photoperiod (day length). Their studies revealed that both domestic and wild birds built their nest, mated and laid eggs during spring time. When day length increases, egg production decreases and may cease completely when day length falls below 12 hours per day. In order to maintain consistent egg production, laying hens need a minimum of 14 hours of light per day (King, 1998). The duration depends upon the age of the chicken and type of housing. However, according to Lewis *et al*. (1992) the sensitivity of the young pullet to an increase in photoperiod varies with age and is at a maximum between 9 and 12 weeks of age, thus increasing the photoperiod at or soon after 18 weeks has little effect on age at 50% lay. With early lay you will get smaller eggs and with late lay you will get fewer larger eggs, but the total egg mass at the end of lay will not be much different. In the temperate region, hens exposed to only natural light would be expected to resume egg production in the spring, (Jacob, *et al*., 2013). An increase in day length is one of several factors that may bring on egg laying in both poultry and pet birds. Harrison, (1972) also reported that a decrease in daily photoperiod can cause an overall decrease in egg production. He observed no significant difference in egg production rates (percentage hen-day production) in photoperiods between 13 and 14 hours. This occurs naturally during the winter months and can be prevented by providing artificial light.

On the other hand, overall health and longevity can also suffer from extended periods of direct sunlight without shade (Mahmud, *et al*., 2011).The decreasing daylength during the fall and shorter daylengths in the winter would be expected to cause a severe decline, or even cessation, in egg production.

2.4 Concept of Light Intensity

2.4.1 The Significance of Light on Poultry

Bird breeders and fanciers around the world have long believed in the benefits of natural sunlight and fresh air (Lewis and Morris, 1998). One of the benefits of light for avian countries is that birds enjoy sun bathing and most captive bird’s species originate from very hot climate such as the popular Australian specie (Louise, 1998). Indeed, responding to light may have had an adaptive value for chickens and turkeys through evolution and may still influence the visual perception and behaviour of the birds today. The intensity of light should be sufficient to allow a person to read newsprint at bird level (Appleby *et al* 1992)

In the tropics, blessed with a climate that permits this, egg production is very closely related to changes in daylenght and light intensity to which birds are exposed influencing egg number, egg size, livability and total profitability. This can be favourably influenced by a proper lighting in the form of illumination (Lewis *et al.* 2005).

2.4.2 Source of Lighting in Poultry

The Council of Europe (CoE, 2001) stated that all buildings shall have light levels sufficient to allow all birds to see one another and be seen clearly, to investigate their surroundings either artificially or naturally in the form of illumination. The light intensity also known as the illuminance or light level described the total amount of power emitted from the visual part of the light spectrum in the form of natural and artificial/supplemented source

2.4.2.1 Artificial source of lighting.

According to the American Society of Agriculture and Biological Engineers (ASAE, 2005), Lamps are light sources available for agriculture lighting applications which include incandescent, fluorescent, low pressure sodium and high intensity discharge (HID). The HID sources include mercury, metal halide and high-pressure sodium lamps. They are more efficient, have longer rated lives, and generate 2 to 5 times more light than the incandescent filament for the same amount of electrical energy. This Engineering Practice is intended to guide those responsible for or concerned with, the design of lighting installations on or within agricultural facilities to supplement where sunlight visibility is lower than recommended.

2.4.2.2 Natural source of lighting

The sun is the only natural source of energy in the form of solar radiation where electromagnetic waves emitted by the sun, varying in wavelength from ultraviolent to infrared waves. The earth gets only 0.0005% of the suns radiation in form of reflection, diffusion, and refraction. Most solar radiation passes straight through the atmosphere without warming it but received and absorbed by the earth (Mayhew, 1997).The visible is just a tiny portion of total electromagnetic spectrum of light environment which can be classified into three ways**;** ***Wavelength or colour of light, Duration*** and ***Light intensity*** as it affects the livestock environment (Leeson and Summers, 1980).

- Wavelength or colour of light

Several studies on the influence of the colour of light (Morris, 1998) have shown that birds are more sensitive to wavelengths toward orange and red and less sensitive to blue, green or yellow, and also that the quality of the light affects the body weight and the abdominal fat deposits (Pryzak et al, 1986) and have many different effects on behaviour, growth and reproduction in poultry.

- Duration

Duration is defined as the amount of daylenght received also known as photoperiod. Photoperiodism describes the effect of increasing or decreasing day length on such aspects of metabolism as the onset of breeding activity (Lewis and Morris, 1998). The duration depends upon the age of the chicken and type of housing. This occurs naturally during the winter months and can be prevented by providing artificial light. According to Lewis *et al*. (1992), inadequate length of sunlight causes a drop in egg production. In order to maintain consistent egg production, laying hens need a minimum of 14 hours of light per day. Some recommended 16 to 18 hours of light daily. Sunlight and artificial light can be combined in order to achieve these minimums. On the other hand, overall health and longevity can also suffer from extended periods of direct sunlight without shade (Mahmud *et al*. 2011).

- Intensity

Light intensity is described as the quantity of light falling on a unit area and is measured with a light meter/lux meter to produce the photometric unit “lux” (Lewis and Morris, 2006). The amount of illumination is received naturally in the form of illumination through the window or transparent roof. The physiological impact of natural light on birds is one of the chief concerns about light quality in regard to Vitamin D metabolism in form of illumination.

2.4.3 Natural versus Artificial Lighting

According to Hagen Avicutural Research Institute (HARI, 1998) Vitamin D is the only vitamin that normally requires a specific type of light - ultraviolet light, which comes from the sun to convert it into its active form. When birds ingest Vitamin D in their food, the sun's ultraviolet fraction converts it into a fundamental component of good health - the chemically active form of Vitamin D3 (25-dihydroxycholecalciferol). Without this exposure to sunlight, Vitamin D deficiency problems such as rickets in birds and soft shell eggs in layers can develop.

In theory, modern medicine has made it possible to compensate for a lack of direct sunlight by feeding the bird artificially produced chemically active form much like our own vitamin supplements but this approach is not without problems. One of the key issues is the correct dosage. Unfortunately, owners who are careless with prescribed doses may be endangering their animal's well-being, as Vitamin D3 may be toxic when given in excess. Frustratingly, we do not know the minimum and maximum safe level of supplements for most bird species. We do know that certain parrots such as the macaws seem to be particularly sensitive to

Vitamin D3 overdose. In fact, typical problems include renal failure, widespread tissue calcification, and breeding difficulties (Louis, 1998).

The issue of Vitamin D supplements, then, demands a lot of thought. But without access to activated Vitamin D the 'indoors' bird cannot absorb calcium normally from its food, and the results are catastrophic (Lewis and Morris, 1998). The best course of action is to use adequate, not excess, Vitamin D3 supplementation, and to provide access to natural unfiltered sunlight or full spectrum light wherever possible.

2.4.4 Light intensity and its measurement

Light intensity is synonymous with illuminance and light level. It describes the quantity of light falling on a unit area and is measured with a light meter (or lux-meter) to produce the photometric unit “lux” (Lewis and Morris, 2006). The readings of a lux-meter will depend upon several factors. Firstly, the readings from a lux-meter will largely depend upon the height of measurements, and specify that the light intensity should be measured at bird eye level (CoE 1995; FAWC 1995; FAWC 1997; CoE 2001; CEU 2007). Secondly, the reading will depend on whether the sensor of the lux-meter is held horizontally, pointed towards maximum illuminance or measured in 3 planes at right angles to each other (Prescott *et al*., 2003; Lewis and Morris, 2006). The photometric unit for measuring illuminance (lux) is adjusted to the human spectral sensitivity. Since the spectral sensitivity of chickens and turkeys is different to that of humans (Wortel *et al*., 1987; Prescott and Wathes 1999, Barber *et al*., 2006), it is not appropriate to use the lux-unit for these species. Indeed, the alternative unit of “clux” (chicken-lux) or “galluiminance” describes the illuminance adjusted to the spectral sensitivity curve of fowl (Prescott and Wathes 1999, Lewis and Morris 2006).

According to Norwegian Scientific Committee for Food Safety (2007), matching the perceived illuminance of different light sources for the particular poultry species is important in order to compare the independent effects of illuminance and light sources with different spectral contributions. For example, due to differences between natural and artificial sources. In artificial lighting husbandry system, chickens will perceive an incandescent light source as approximately 30% brighter than a fluorescent light source, when these are measuring the same lux-values. In addition, a common error in studies on light intensity has been used by using a voltage dimmer to adjust incandescent light sources to different light intensity levels. This is problematic since this method of dimming an incandescent light source will change the colour of the light as well as the light intensity, and any effect of the different light conditions may be due to either the difference in light intensity or the difference in light colour.

2.5 Chicken egg Production and Husbandry

2.5.1 Chicken egg production

The laying cycle of a chicken flock usually begins at 16–22 weeks of age with daily production of about one egg per bird, depending on the breed, age and season under good management. Production gradually declines soon after approximately 25 weeks of age to about 65% after 12 months of lay (Hyline International, 2011). This means that in many countries, by approximately 72 weeks of age, flocks are considered economically unviable and are slaughtered after approximately 12 months of egg production (DEFRA 2011). Although chickens will naturally live for 6 or more years and continue to lay eggs for many of these years, after two or three years many hens significantly decline in productivity. This varies greatly from bird to bird. Good layers will lay for about 50 to 60 weeks and then have a rest period called a molt. Poorer layers and older hens will molt more often and lay less consistently. In some countries, hens are force moulted to re-invigorate egg-laying. Thus egg production becomes uneconomic since feed consumption increases, egg production declines while weight of egg increases resulting to soft shell egg.

A typical production curve for a laying flock, showing changes in the level of egg production and in egg weight, over time is given in figure 2.1.

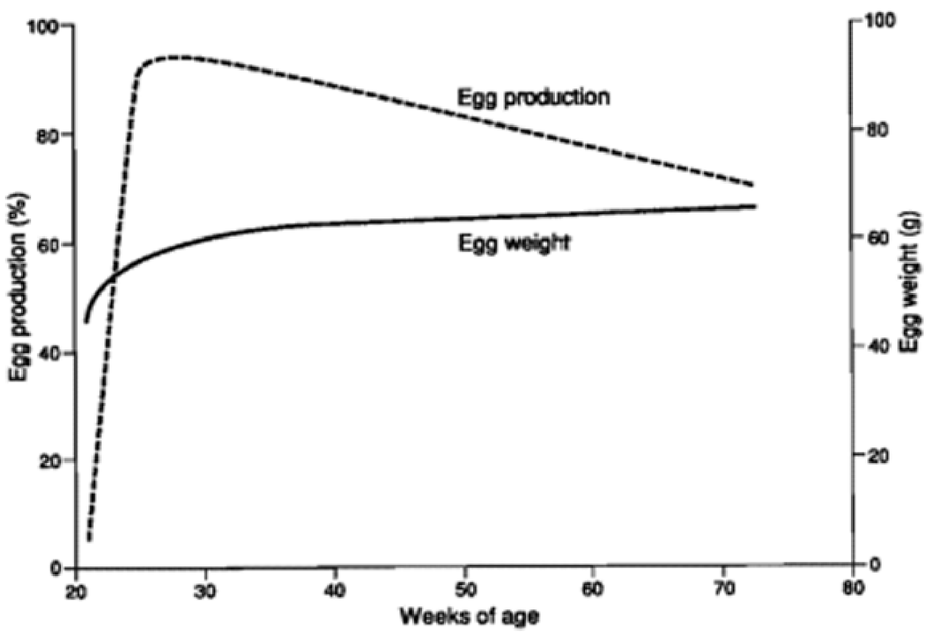

Figure 2.1: A typical production curve for a laying flock
Source: DEFRA (2011)

As shown in figure 2.1, layers begin laying eggs at 20 weeks of age and reach its peak before 25 weeks while production gradually declines after 25 weeks of age. Also egg production declines while weight of egg increases.

There are many factors that can adversely affect egg production. Unravelling the cause of a sudden drop in egg production requires a thorough investigation into the history of the flock. Egg production can be affected by factors such as feed consumption (quality and quantity), water intake, intensity and duration of light received, parasite infestation, disease, and numerous management and environmental factors (Jacob *et al*., 2013).

2.5.2 Housing System for Poultry Production

According to the World Watch Institute (2006), 74 percent of the world's poultry meat, and 68 percent of eggs are produced in ways that are described as intensive poultry farming and free-range.

2.5.2.1 Free Range.

Free-range poultry farming allows chickens to roam freely for a period of the day, although they are usually confined in sheds at night to protect them from predators or kept indoors if the weather is particularly bad. In the UK, the Department for Environment, Food and Rural Affairs (DEFRA, 2011) stated that a free-range chicken must have day-time access to open-air runs during at least half of its life. Unlike in the United States, this definition also applies to free-range egg laying hens.

The European Union (2011) regulates marketing standards for egg farming which specifies a minimum condition for free-range eggs that "hens have continuous daytime access to open-air runs, except in the case of temporary restrictions imposed by veterinary authorities. The welfare standards for laying hens and pullets indicates that the stocking rate must not exceed 1,000 birds per hectare (10 m^2 per hen) of range available and a minimum area of overhead shade/shelter of 8 m^2 per 1,000 hens must be provided.

Free-range farming of egg-laying hens is increasing its share of the market. DEFRA (2011) figures indicated that 45% of eggs produced in the UK throughout 2010 were free-range, 5% were produced in barn systems and 50% from cages. This compared with 41% being free-range in 2009.

Free-range farmers have less control than farmers using cages in what food their chickens eat, which can lead to unreliable productivity. The benefits of free-range poultry farming for laying hens include opportunities for natural behaviours such as pecking, scratching, foraging and exercise outdoors (DEFRA, 2011). In some farms, the manure from free-range poultry can be used to benefit crops.

2.5.2.2 Intensive poultry farming

Intensive poultry farming includes the following:

- *Yarding*

It is actually a separate method of poultry culture by which chickens and cows are raised together. The distinction is that free-range poultry are either totally unfenced, or the fence is so distant that it has little influence on their freedom of movement. Yarding is common technique used by small farms in the Northeastern US. The birds are released daily from hutches or coops. The hens usually lay eggs either on the floor of the coop or in baskets if provided by the farmer and can be complicated if used with roosters, mostly because of aggressive behaviour (DEFRA, 2011).

- *Battery cage system*

The majority of hens in many countries are reared in battery cages, although the European Union Council Directive (1999) has banned the conventional battery cage in EU states. These are small cages, usually made of metal in modern systems, housing 3 to 8 hens. The walls are made of either solid metal or mesh, and the floor is sloped wire mesh to allow the faeces to drop through and eggs to roll onto an egg-collecting conveyor belt. Water is usually provided by overhead nipple systems, and food in a trough along the front of the cage replenished at regular intervals by a mechanical chain. The cages are arranged in long rows as multiple tiers, often with cages back-to-back (hence the term 'battery cage'). Within a single shed, there may be several floors containing battery cages meaning that a single shed may contain many tens of thousands of hens. Light intensity is often kept low to reduce feather pecking and vent pecking. Benefits of battery cages include easier care for the birds, floor eggs which are expensive to collect are eliminated, eggs are cleaner, capture at the end of lay is expedited, generally less feed is required to produce eggs, broodiness is eliminated, more hens may be housed in a given house floor space, internal parasites are more easily treated, and labour requirements are generally much reduced (DEFRA, 2011).

In farms using cages for egg production, there are more birds per unit area; this allows for greater productivity and lower feed costs (VEGA, 2007). Floor space ranges upwards from 300 cm^2 per hen. EU standards in 2003 called for at least 550 cm^2 per hen. In the US, the current recommendation by the United Egg Producers is 67 to 86 in^2 (430 to 560 cm^2) per bird. The space available to battery hens has often been described as less than the size of a piece of A4 paper. Animal welfare scientists have been critical of battery cages because they do not provide hens with sufficient space to stand, walk, flap their wings, perch, or make a nest, and it is widely considered that hens suffer through boredom and frustration through being unable to perform these behaviours (Appleby *et al*., 2004).This can lead to a wide range of abnormal behaviours, some of which are injurious to the hens or their cage mates.

- Commercial furnished cage system

In response to these bans, development of prototype commercial furnished cage systems began in the 1980s. Furnished cages, sometimes called ‘enriched’ or ‘modified’ cages, are cages for egg laying hens which have been designed to overcome some of the welfare concerns of battery cages whilst retaining their economic and husbandry advantages, and also provide some of the welfare advantages of non-cage systems. Many design features of furnished cages have been incorporated because research in animal welfare science has shown them to be of benefit to the hens. In the UK, the DEFRA (2011) "Code for the Welfare of Laying Hens" stated that furnished cages should provide at least 750 cm^2 of cage area per hen, 600 cm^2 of which should be usable; the height of the cage other than that above the usable area should be at least 20 cm at every point and no cage should have a total area that is less than 2000 cm^2. In addition, furnished cages should provide a nest, litter such that pecking and scratching are possible, appropriate perches allowing at least 15 cm per hen, a claw-shortening device, and a feed trough which may be used without restriction providing 12 cm per bird.

- Indoors husbandry system

The floor system is mainly practiced in the tropics also referred to as deep litter husbandry system. It consists of an open sided house with dwarf wall of less than a meter height while the rest of the building is made up of wire mesh nailed to wooden pillars for adult birds (Atanda, 1991). They are raised in large, open structures known as grow out houses. Some houses are equipped with mechanical systems to deliver feed and water to the birds. The modern ones have ventilation systems and heaters that function as needed. The floor of the house is covered with bedding material consisting of wood chips, rice hulls, or peanut shells because dry bedding helps maintain flock health, most grow out houses have enclosed watering systems (“nipple drinkers”) which reduce spillage (National Chicken Council, 2012).

Keeping birds inside a house protects them from predators such as hawks and foxes. Some houses are equipped with curtain walls, which can be rolled up in good weather to admit natural light and fresh air. Most growout houses built in recent years feature “tunnel ventilation. In intensive sheds, the air can become highly polluted with ammonia from the droppings. This can damage the chickens’ eyes and respiratory systems and can cause painful burns on their legs called hock burns and feet (National Chicken Council, 2012).

Chickens are kept indoors but with more space with 12 to 14 birds per square meter. They have a richer environment for example with natural light or straw bales that encourage foraging and perching. The benefits of higher welfare indoor systems are the reduced growth rate, less crowding and more opportunities for natural behaviour (DEFRA, 2011).

2.6 Recommendations and regulations on lighting for poultry

Studies have been carried out to analyze the effect of physiological impact of artificial light intensity on laying birds depending on the specie and colour, type of housing and with respect to the various regions in the world. Several recommendations and regulations on lighting for poultry exist, both for broiler chickens, laying hens and turkeys. The Council of Europe (CoE, 1995) recommended that all buildings are required to have sufficient light with minimum illumination level of 20 lux at bird eye level to identify, explore their surroundings without difficulties.

The Farm Animal Welfare Council in the UK (FAWC, 1992) considered 20 lux as suitable average light intensity. They also set the absolute lowest average light intensity at 10 lux. Also the Farm Animal Welfare Council (FAWC, 1997) recommended a minimum of 5 lux with regards to lighting intensity for laying hens in perching and feeding areas and to give birds time to roost especially for enriched cages.

The Council Directive of Europe (2007) based on a report by the Scientific Committee for Animal Health Welfare (SCAHAW, 2001) concluded that brighter lightening above 100 lux is important to stimulate activity and welfare of the birds.

2.7 Findings from Literature Review

The review revealed a step by step development of light intensity assessment methods and concepts through the years starting from the early 19^{th} century. Most of the findings of the researches were based on artificial source of light in a controlled environment.

Early in the 19th century, poultry farmers in the state of Washington, USA found that they could increase winter egg production by placing linted lantern in the chicken house for a few hours in the evening. At that time it was thought that the role of light was primarily a matter of increasing the workday of the bird. Ensminger (1980) in reviewing the historical perspective in the early century as poultry farmers in the state of Washington, USA found that the ancient Chinese made their canaries sing by placing lighted candle in the cage at night.

Wagener (1950) observed that light and heat had stimulating effects on egg production and higher performance. He observed that birds receiving heat and illumination in winter months had a higher performance than those with heat alone. When production ceases, the birds may also undergo a feather molt.

Sainsbury (1976) revealed in his studies that light had great influence on egg production in birds kept intensively affecting feed consumption reproduction and behaviour. He proposed further that light intensity should never go below 5 lux for layers. Martin (1989) found that laying hens were more active in 500 lux than in 50lux which also had effect on egg production.

The study of Atanda (1991) on the effects of cage location, tier level, exposure and age of bird on egg production in Ondo State, Nigeria in a natural environment revealed that more eggs were laid in the morning than in the evening and could be attributed to lighting conditions. It was also revealed that birds lay eggs in the light and not in the dark because hormones causing ovulation is controlled and responds to signals such as light therefore recommended more light in the laying pens for increased egg production but didn't specify the amount of lux.

Appleby *et al*., (1992) recommended light intensity for laying hens should be sufficient to allow a person to read newsprint at bird level. Tucker and Charles (1993) found that layers did not respond differently to 0.75 lux and 12.4 lux in terms of egg production. Despite this, they recommended a light intensity of at least 10 lux on the grounds of welfare and staff working conditions

Morris (1994) found that in the Europe light intensity of about 5 lux is adequate for laying hens using artificial light but recommended that light intensity for laying hens are selected on the basis of the working conditions of the staff as well as ensuring adequate inspection of the flock, rather than the physiological needs of the birds. Therefore suggested that the laying performance of hens is relatively insensitive to light intensity.

Lewis and Morris (1999) comprehensively reviewed the evidence available on the light intensity required for the performance of laying hen. Based on the available data from earlier studies, they recommended that for optimizing the rate of lay, the light intensity should not be less than 5 lux but found no adverse effects on laying.

Prescott and Wathes (2002) found that hens (ISA brown) showed a strong and active preference for feeding under bright illuminances (200 lux) rather than very dim light (<1 lux) with illuminances of 20 lux and 6 lux intermediate between the bright and dim light. Also laying hens consumed significantly less feed, pecked less with illuminance <1 lux compared with 6, 20 and 200 lux of incandescent light. They also showed significant effect on egg weight and numbers with feed intake.

Hyline international (2011) recommended the minimum lighting program in controlled housing for their brown laying hens within a range of 10-15 lux and 20 lux for natural ventilated housing. They also stated that this recommendation on light intensity is only a guide as increase in light could result in an over consumption of feed and may cause EODES (Eratic Ovulation and Defective Egg Syndrome).

On the other hand, overall health and longitivity can also suffer from extended periods of direct sunlight without shade (Mahmud *et al*., 2011). Much is known about the effect of supplemented lighting on poultry, although some essential questions still need to be addressed.

CHAPTER THREE: MATERIALS AND METHODS

This chapter presents the study area in terms of its location, position and the general characteristics of the area (climate, relief and drainage, vegetation, geology, soils, people and population). It also describes the method used in data collection and analysis.

3.1 Study Area

3.1.1 Study Location

The study area "Samaru" is located 18 kilometres North-West of Zaria along the Zaria-Sokoto road. It is a suburb of Zaria in Kaduna State, Nigeria. It is situated between latitude 11^0 04"N to 11^0 12" North of the Equator and longitude 07^o 37" E to 07^o 40" East of Greenwich Meridian (figure 3.1). Zaria is one of the provinces that make up the Central high plains of Northern Nigeria at an altitude of 550-700 meters above sea level. Samaru town is the fourth and the most recent addition to the Zaria suburban area made up of Zaria-City, Tudun-Wada, the Government Reservation Area (GRA), and Sabon-Gari. Samaru evolved from a small colonial farming settlement to become a large community, a melting-pot, often referred to as "the University village"(Sawa and Buhari, 2011) Zaria itself is second very largest, heterogeneous city with about1.490, 000 population. It is accessible from different parts of the country by air via Kaduna, Kano, and Abuja and by rail and road via Kaduna, Jos, Kano and Sokoto (Sawa and Buhari, 2011).

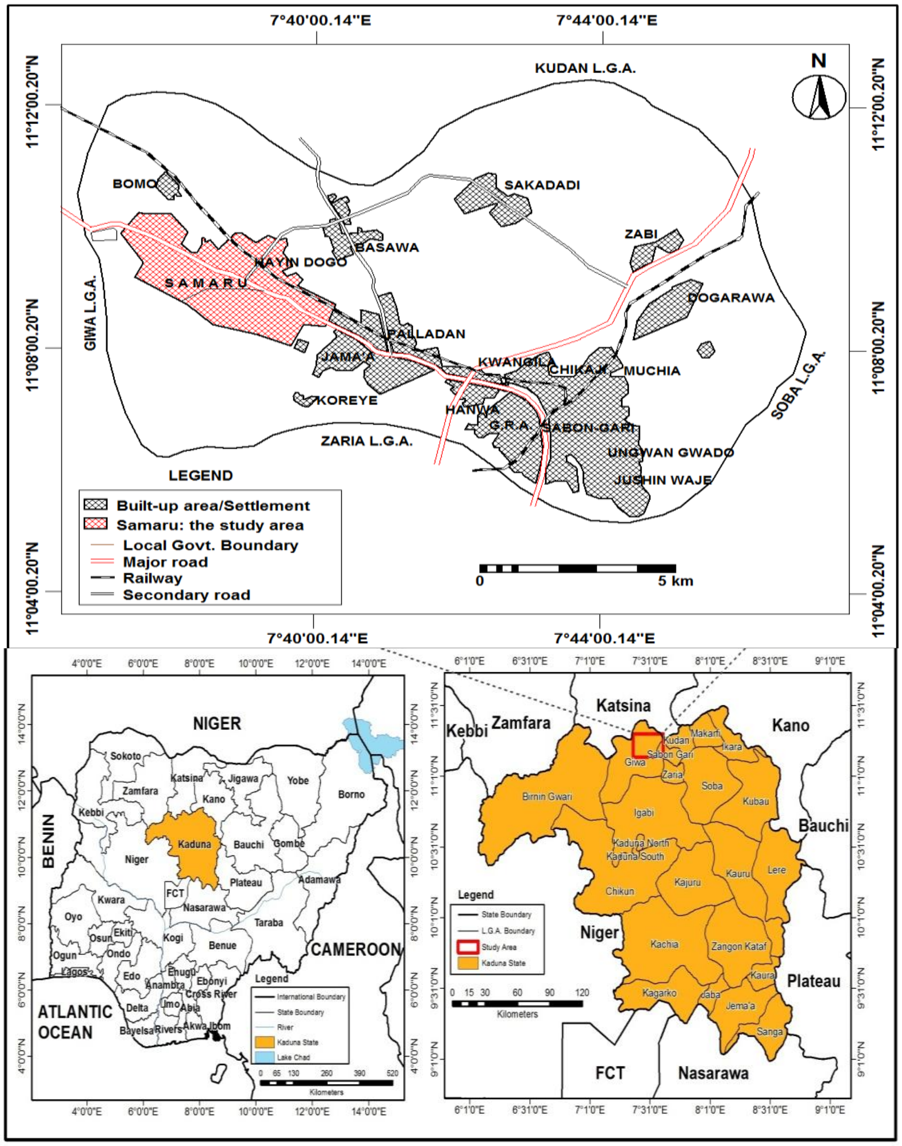

Fig. 3.1: Sabon Gari Local Govt. Area Showing Samaru: The Study Area
Source: Adapted and modified from Topo Map of Zaria Sheet 102 S.W

3.1.2 Climate

According to the Thonthwaite's Scheme, the climate of Zaria is the dry sub-humid type (Ogbaji, 2006). The gross features of rainfall pattern in this region, as in other Parts of Nigeria are usually in association with what is often called the inter-tropical discontinuity (ITD) (Nicholson, 1981; Kanote, 1984; Oladipo, 1993). The ITD itself is the boundary at the ground between the dry tropical continental (cT) air of northern origin and the cool moist tropical maritime (mT) air of southern origin. These two air masses pass through and are responsible for the seasonal changes in Zaria climate. Sticky hot weather conditions prevail during the northward movement of the ITD because of small diurnal temperature range, high relative humidity with little or scanty showers of rainfall, in the southward movement, associated with dry and cold weather condition because of great diurnal temperature range and low relative humidity with no rainfall (Ogbaji, 2006; Hayward and Oguntoyinbo, 1987).

On the basis of these two air masses and their subsequent weather, the year in Zaria is broadly classified as wet and *dry* seasons (Ogbaji, 2006):

i. Wet season (lasting from April to October)
ii. Dry season (lasting from October to March)

The onset of the wet season in April begins with light showers once or twice and between May and June considerable thunderstorm occurs and the rains begin to get steadier. Between July and October the wet season proper comes on (Oshaji, 2000). While May marks the onset of the rain and the end of the hot season, October usually marks the end of the wet season and the beginning of dry season. With the onset of the wet season, the daily maximum temperature drops and the diurnal range of temperature becomes low. July and August in

Zaria are the months of mildest weather (Oshaji, 2000). The diurnal range of temperatures during this period varies from 6.7°C to 9.4°C. The mean daily maximum temperature range in this period is about 26.7°C to 28.9°C. Cloudiness reaches maximum in August and consequently, the hours of sunshine are at the least. The average duration of sunshine in August varies from 3 to 6 hours. The relative humidity is very high only during the raining season in August (about 83-85 percent) but drops during the dry season to a minimum of about 16%. The annual range of relative humidity varies from 16.8 to 85 percent (Sawa and Buhari, 2011). Relative humidity drops from 60-65 percent in October to about 16 to 17 percent in December.

The daily minimum temperature at the beginning of the dry season drops more rapidly than the maximum. Consequently, the diurnal range of temperatures increases rapidly. The sky is mostly clear in November which permits longer hours of sunshine. In early November, morning and nights become cooler and pleasant. Dust haze begins to appear and increases in frequency as the harmattan wind is being introduced. In December to January, the haze and dust layer of the harmattan sometimes creates poor visibility (Hore and Mortimore, 1970).

The study area lies on a Plain land ranging in height from 550-700m, which is an extensive peneplain developed on crystalline metamorphic rocks of the Nigerian basement complex. There is however, some inselbergs such as Kufena hill and some low quartzite ridges in the west that remains upstanding. Major inselbergs include Kufena hill, Turunku inselberg. Dutsenwai hill. Others include those of Hange, Dumbi, Farankwai, Tukur – Tukur and Madarkaci (Smith, 1970).

This plain is being drained by River Kubani with its numerous tributaries. This river becomes heavily flooded during the rains and dries up during the dry season. Alluvial soils which occur along this river are used for dry season farming. There are no major high surfaces or inselberges but there are some marshy surfaces and rivers. River Kubanni which formed the main focus of the drainage system is a tributary of Galma River which has water throughout the year while River Kubanni dries up in the period between January and June (Mortimore and Wilson, 1965).

3.1.3 Geology

Zaria is underlain by three groups of rocks all of which belong to the Precambrian basement complex of Nigeria. These groups of rock include:

a. Gneiss of variable composition, which include granite rocks gegmatite or schists, which have been thoroughly weathered at various depths and are found to form most of the superficial materials which are generally called drift.
b. Quartz, schist and quartzite which form a narrow bed of low rounded hill and valley topography.
c. Gneiss or porphyritic granites are characterized by inselbergs of different shapes and sizes; these are often referred to as the older granite. They cover a small area with largest outcrop forming the Kufena group of inselbergs. (Alkali, 2009).

The geologic materials of the study area are composed mainly of fine-grained biotite gneiss and migmatites, with some coarse-grained granitic outcrops in a few places. The gneisses are moderately to weakly foliated, principally made up of quartz and oligoclase (Du preez and Barber, 1965).

Superficial deposits include young and old laterites, as well as young and old alluvium. Thorough and deep chemical weathering has developed thick lateritic regolith of varying degrees of induration. The laterites are different in morphological character and occur at different levels of the valley side slope profiles. The massive and hardened laterites form older laterites (vermicular and vesicular types) and occur at high levels on the upland and close to the interfluves as mesas and buttes. As the older laterites are destroyed by erosion, the rubble is transferred to gentle sloping surface at lower levels where it undergoes re-concretion to form what has been described as younger laterites (Pullan, 1970, Ologe, 1972; Bello, 1973).

The older alluvium is made up of brown to brownish red, fine to medium-grained, fairly undulated sands, clay and gravels. The younger alluvium which are mostly unconsolidated, are made up of grey-brown sands, silts and clay. Ololobou (1982) observed an excellent site, which occurs about 0.5km upstream from the bridge along Zaria by-pass. Within the Kubanni basin, the presence of younger laterite with recent alluvial deposits along the river are prominent, there exists a crust belt occurring across the Kubanni basin with recent alluvial deposits along the dam impoundment.

3.1.4 Soil and Vegetation

The soil reflects the geology, climate and vegetation of the area. Zaria soil is grouped to be among the leached ferruginous tropical soils. The soils of these group are normally heavily worked, drainages being very poor on account of the high percentage of fine materials in the upper layers. Most of the soil is 30-40% rich in clay, which have the ability to retain moisture. It becomes waterlogged with rains and also cracks during rainy season. Alluvial soils occur especially along the rivers and streams (Niniola 1999).

Along the fadamas are found hydromophic soils in the flood plains which allow for the cultivation of sugarcane, cassava, yam and coco-yam. The soil are generally hard to cultivate, hence it requires the use of heavy implements.

The vegetation of the area falls into the guinea savannah belt. Even though there has been so much felling of trees for fuel purposes and bush burning by hunters, there are still patches of savannah woodland with tress rising to heights of between 6-12 meters. There are also shrubs in the area characterized by varieties of grasses. The appearance of vegetation however, changes with season. This is because during the rainy season, the vegetation is usually fresh and green while in the dry season, they appear brownish yellow, looking withered and un-healthy (Rains, 1963 and Ologe, 1972). The dominant species are the annual grasses interspaced with shrubs, herbs and deciduous trees. The scanty vegetation cover enhances surface run off due to low infiltration. This concurrently causes pollution of rivers and other environmental problems to the people.

3.2 Materials and Methodology

3.2.1 Data Types Used

Based on the scope of the study, aim and objectives, the types of data used for this research were as follows:

1. Daily illumination reading throughout the research period of 20 weeks.
2. Daily records of eggs throughout research period.

3.2.2 Sources of Data

All the data used for this research were of primary and secondary source. Literature was obtained from secondary sources through the consultation of related books, journals, articles, information from the library research, conference papers, on-line publications, and other relevant materials.

3.2.3 Experimental birds and their Management

It was an experimental research consisting of 60 commercial ISA Brown pullets purchased from a commercial hatchery and upon arrival; the chicks were brooded and raised together until at 30 weeks of age, birds were allocated randomly and used for the period of 20 weeks. The pullets were given all the necessary vaccines and medication throughout the research period, according to Ahmadu Bello University Vetnary Teaching Hospital (ABUVTH, 2013) recommendation.

The laying hens for this experiment were fed on the same quantity and quality feed and water. There was uniformity in the management and inspection of flocks such as packing of dung, collection of eggs. The birds were fed and watered ad libitum, with a commercial layer mash containing 2750Kcal. metabolisable energy per kilogramme and 16% crude protein as the standard requirement. Drinking water was restricted only during the process of vaccinating the birds while feed was equally administered in the quantity of 125 grams per bird as recommended by ABUTH (2013).

Throughout the experiment, the birds were placed in their respected pens and were not moved or replaced except when there was need for replacement in case of mortality and there was none. Also eggs were collected for weighing grading and were also counted in the morning and in the afternoon.

3.2.4 Experimental Design

The experimental bird husbandry was based on indoor husbandry system mainly practiced in the tropics also referred to as deep litter husbandry system. It consist of an open sided house with dwarf wall (made of cement block) of 0.3 meter height while the rest of the building was made up of wire mesh nailed to wooden pillars of about 2 meters height. The house was divided into three experimental unit light treatment pen with a total area of about 3 square meters. Twenty birds were kept in each pen according to the recommendations of this type of husbandry system by DEFRA (2011).

The pens were equipped with manual systems placed directly on the wood chip to deliver feed and water to the birds. The floor of the house was covered with bedding material consisting of wood chips in order to maintain flock health. The variations of sunlight were achieved by controlling the penetration of light using window side cover, opaque and transparent roof covers.

The sunlight intensity program treatment for the pens in this research is based on literature review having minimum range in the early morning and late hours of the day with maximum range during the day time. From left to right are pen 1 (Low illuminance), pen 2 (Moderate Illuminance) and pen 3 (High Illuminance) respectively as shown in plate 1;

Plate 1 shows the experimental husbandry unit before transferring birds in the early morning hours. The floor of the house was covered with bedding material consisting of wood chips.

Plate 1: Experimental husbandry unit pen 1: No. 5 Sulu Gambari Lane area C, Ahmadu Bello University Zaria.

Pen 1: Low illumination ranging 5 to less than 20 lux with 100% opaque roof cover. The three side covers for this light treatment was low transparency except for the fourth side which was left uncovered for ventilation.

Pen 2: Moderate illumination ranging from 20 to 200 lux. This was achieved by replacing 10 percent of the total opaque roof cover with a transparent roof. Also the three side covers were of low transparency except for the fourth side which was left uncovered for ventilation.

Pen 3: High illumination of 200 lux and above, this was achieved by replacing 20 percent of the total roof cover with a transparent roof. As for the side covers, two were of low transparency, the third was transparent while the fourth side was left uncovered for ventilation.

Plate 2 shows the experimental husbandry unit with birds in after five weeks of adapting to the new environment. The birds were kept indoors with space of about 20 birds per 3 square meters as shown in plate 2 below.

Plate 2: Experimental husbandry unit pen 2: No. 5 Sulu Gambari Lane area C, Ahmadu Bello University Zaria.

Plate 2 shows the variations in light level in the afternoon and bird’s activities such as sun bathing, pecking were displayed in pen 3 while bird’s in pen 1 seems to be less active.

The measurement and reading of a lux-meter was illustrated in one of the pens as shown in Plate 3.

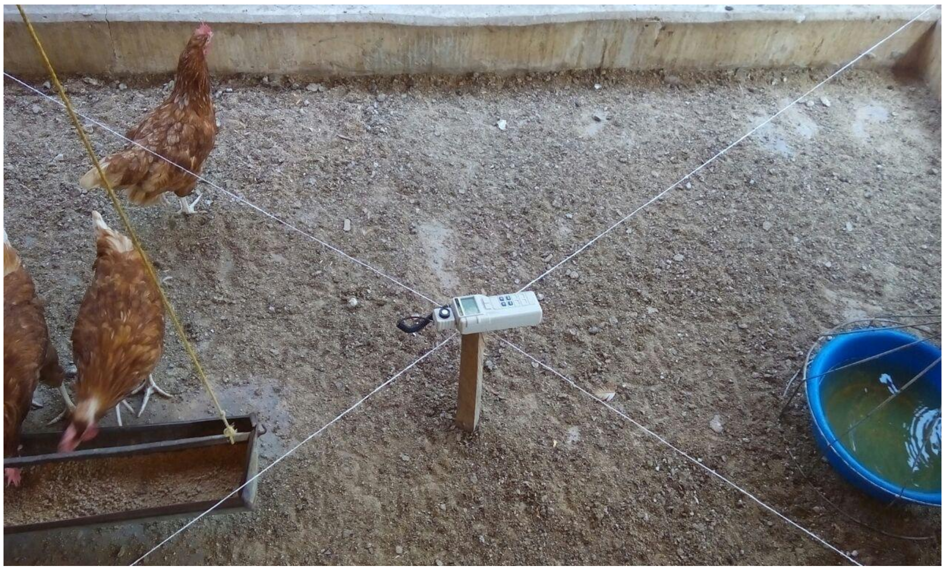

Plate 3: Experimental husbandry unit pen 3: No. 5 Sulu Gambari lane area C, Ahmadu Bello University Zaria.

Firstly, the reading was taken by aligning the lux-meter proportional to the height of the bird's eye level which is about 30 cm for laying hens. Secondly, the readings of the sensor (lux-meter) was held horizontally measured in 3 planes at right angles to each other as illustrated using a string and stand to place the light meter to get the alignment in order to prevent casting shadow that could cause error.

3.2.5 Data Collection

The environmental factor measured was illuminance, this was taken 3times during the day time at interval of 5 hours (8.00 am, 1.00pm and 6.00pm) within their activity period for feeding, laying and other behaviours such as pecking sun bathing and others. The measurement taken at different hours of the day was to ensure that the light levels were maintained within the stated range. A histogram chat of the three pens on number of eggs, weight and number of cracked eggs were drawn to show Disparities of different light intensity in chicken egg production. Finally, in order to determine the statistical relationship between variations in light intensity and chicken egg production, Multiple analysis of variance was used. Descriptive statistic was used to determine how much of the variations in chicken egg production is accounted by variations in light intensity. There was no record of mortality but activities and other behaviours such as pecking and cannibalism, sun bathing and others were observed within the various pens.

Eggs were collected at interval of two hours from 8.00am to 6.00pm daily and graded immediately after the last day's collection. Eggs were weighed using an electronic digital scale within a permanent position to minimize errors, and graded according to the grading system as shown in table 3.1

Table 3.1 Weight range per egg measured in grams

Egg Grade	**Weight in Grams**
Extra Large	64 Above
Large	57-63
Medium	50-56
Small	43-49
Peewee	<43

Source: Adapted from Atanda (1991) and DEFRA (2002).

The percentage in terms of production was calculated daily and weekly.

$$\text{Daily Production \%} = \frac{\text{Number of Eggs}}{\text{No of Birds}} \times 100$$

3.3 Statistical Analysis

Both the descriptive and inferential statistical methods were adopted in the analysis of data. While some of the descriptive statistics include the use of mean, standard deviation and coefficient of variation those of the inferential statistics employed include the use of multiple analysis of variance to find out whether relationship exist between variations in sunlight intensity and chicken egg production on poultry in the study area and hypotheses were tested using univariate (one-way ANOVAs) at $p \leq 0.05$ levels of significant. A one-way between groups multivariate analysis of variance was performed to investigate sunlight differences on number, weight and number of cracked eggs. Three dependent variables used were; number, weight and number of cracked eggs. The independent variable was sunlight. Initial testing was conducted to check for normality, linearity, homogeneity of variance-covariance matrices and multicollinearity, with no violations noted.

CHAPTER FOUR: RESULTS PRESENTATION AND ANALYSIS

4.1 The Effects of Variations in Sunlight Intensity and Number of Eggs Produced.

4.1.1 Variations of Sunlight Intensity on Mean daily Egg Production

Based on the daily data, the mean daily production percentage of eggs produced within the study period are presented in table 4.1

Table 4.1 Variations of Sunlight Intensity on Mean daily Egg Production

Level of Sunlight intensity	Egg Production (Percentage)
Low	78.8%
Moderate	78.3%
High	82.1%

Result in table 4.1 Indicates that the daily mean egg production capacity among the laying hens was at its peak at high illumination. This signifies that the higher the sun light intensity, the higher the percentage production of eggs in laying hens.

4.1.2 Variations of sunlight intensity on mean number of eggs per chicken

The mean number of eggs produced per chicken with variations to sunlight intensity within the study period are presented in Figure 4.1

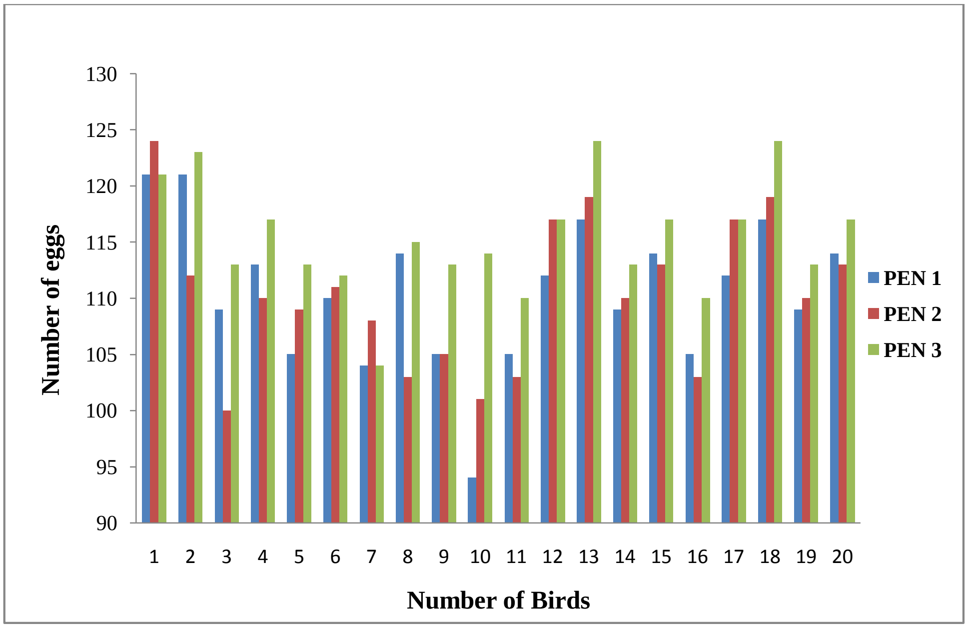

Figure 4.1 ***Variations of Sunlight Intensity on Mean number of Eggs per Chicken***

The result in figure 4.1 indicates that within the study period, low illumination (pen1) has number of eggs ranging from 90 to 120 eggs per chicken, the moderate illumination (pen 2) has number of eggs ranging from 100 to 120 eggs per chicken while high illumination (pen3) has number of eggs ranging from 100 to 125 eggs per chicken,. These results have shown that the higher the illumination, the higher the number of eggs in laying hens.

4.1.3 Mean Standard Deviation of effect of sunlight variation on number of eggs produced

The Mean Standard Deviation as presented in table 4.2 shows the effect of sunlight variations on total number of eggs produced.

Table 4.2: Variations in Sunlight Intensity on Mean Number of Eggs Produced

Level of Sunlight Intensity	N	Mean no of Eggs	Standard deviation	df	Mean Difference
Low	20	110	6.468	2	4.176
Moderate	20	110	6.627	2	
High	20	115	5.029	2	

Result in table 4.2 shows that the number of eggs produced was at its peak at high intensity with a mean difference of approximately 4 eggs. This indicates that the number of eggs produced measured with respect to light intensity indicates that there was less dispersion about the mean with respect to higher illumination.

4.2 The Effects of Variations in Sunlight Intensity and Weight of Eggs Produced.

4.2.1 Variations of Sunlight Intensity on daily Mean weight of eggs produced

Based on the daily data, the mean daily weight of eggs produced within the study period using the egg grading system are presented in table 4.3

Table 4.3: Variations of Sunlight Intensity on Daily Mean Weight of egg production

Level of Sunlight Intensity	Weight in Grams	Egg Grade range in grams
Low	62	Large (57-63)
Moderate	63	Large (57-63)
High	65	Extra Large (64-70)

Result in table 4.3 Indicates that the daily mean weight production of eggs per grams using the weight range egg grading adapted from Atanda (1991), DEFRA (2011). Large eggs were laid under low and moderate illumination while extra large eggs were produced under high illumination. This signifies that egg weight was at its peak at high intensity that is the higher the light intensity, the higher the weight of eggs produced in laying hens.

4.2.2 Variations of sunlight intensity on mean weight of eggs produced per chicken

The mean weight of the total eggs produced per chicken with variations to sunlight intensity within the study period are presented in Figure 4.2

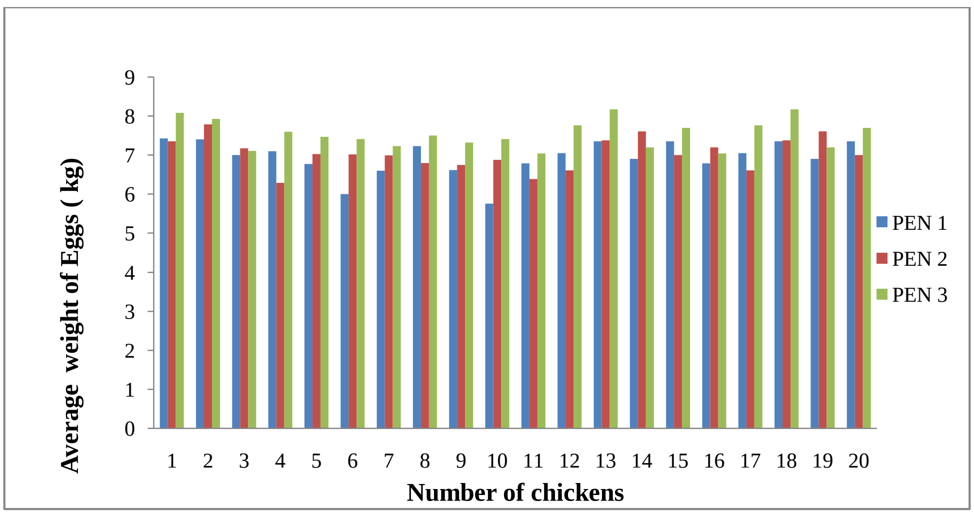

Figure 4.2 *Variations of Sunlight Intensity on Mean Weight of Eggs Produced Per Chicken*

The result in figure 4.2 indicates that within the study period, the total weight of eggs per chicken under low illumination (pen 1) ranging from 6 to 8kg, the moderate illumination (pen 2) ranging from 6 to 8kg, while high illumination (pen 3) ranging from 7 to 8kg.. These results have shown that the higher the light intensity, the higher the weight of eggs in laying hens.

4.2.3 Mean Standard Deviation on the effect of sunlight variation on weight of eggs produced

The Mean Standard Deviation as presented in table 4.4 shows the effect of sunlight variation on total weight of eggs produced within the study period.

Table 4.4: Variations in Sunlight Intensity on Mean Weight of Eggs Produced

Level of Sunlight Intensity	N	Mean weight of Eggs	Standard deviation	df	Mean Difference
Low	20	6.9395	0.44913	2	0.600
Moderate	20	7.0355	0.39997	2	
High	20	7.5400	0.36201	2	

Result in table 4.4 shows that the weight of eggs produced was at its peak at high intensity with a mean difference 0.600 grams. This indicates that the weight of eggs produced measured with respect to light intensity indicates that there was less dispersion about the mean with respect to higher illumination.

4.3 The Effects of Variations in Sunlight Intensity on Number of Cracked Eggs Produced.

4.3.1 Daily mean data on the effects of sunlight variations on cracked eggs produced

Based on the daily data, the extend of variations in sunlight intensity on the daily mean cracked eggs produced within the study period are presented in table 4.5

Table 4.5: Variations of Sunlight Intensity on Daily mean number of cracked eggs

Level of Sunlight Intensity	Number of Cracked Eggs (Percentage)
Low	0.0066%
Moderate	0.0068%
High	0.0073%

Result in table 4.5 shows that the daily mean percentage of cracked eggs increases with higher light intensity produced among the laying hens. Though there was no much difference in number of cracked eggs with respect to variations in illumination.

4.3.2 Variations of sunlight intensity on mean weight of eggs produced per chicken

The mean number of cracked eggs produced per chicken with variations to sunlight intensity within the study period is presented in Figure 4.3

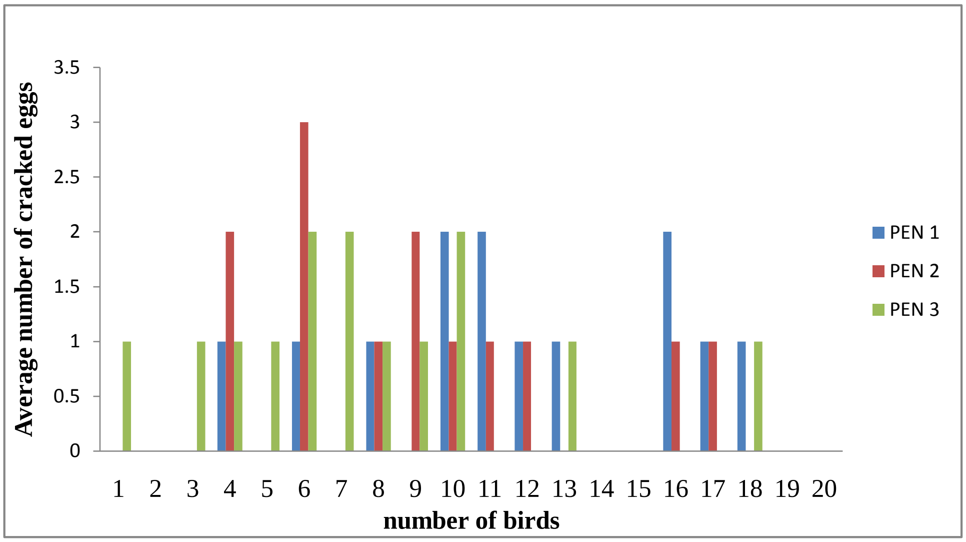

Figure 4.3 ***Variations of Sunlight Intensity on Mean number of cracked Eggs Produced per Chicken***

The result in figure 4.3 indicates that within the study period, the total number of cracked eggs per chicken under low illumination shows few number of cracked eggs in comparison to high illumination, this signifies high number of cracked eggs with increase in illumination.

4.3.3 Mean Standard Deviation of effects of light intensity and number of Cracked Eggs Produced

The Mean Standard Deviation as presented in table 4.6 shows the effect of sunlight variation on total number of eggs produced.

Table 4.6: Variations in light intensity and number of Cracked Eggs Produced:

Level of Sunlight Intensity	Mean no of Cracked Eggs	N	Standard Deviation	df	Mean Difference
Low	0.6500	20	0. 7451	2	0.142
Moderate	0. 6500	20	0. 8750	2	
High	0. 7000	20	0.73270	2	

Result in table 4.6 shows that the daily mean percentage of cracked eggs increases with higher light intensity with a mean difference of 0.145. Though there was no much difference in number of cracked eggs with respect to variation in illumination.

4.4 Hypotheses Testing

This section tests hypotheses of the study. This is to show if variations in sunlight intensity has effects on egg production in chicken within the study period.

4.4.1 Test for Sunlight Variations on Number of Eggs Produced

Analysis Of Variance (ANOVA) statistical technique was employed at 0.05 significant level to test for sunlight variations on number of eggs produced. The result for hypothesis is presented in Table 4.7

Table 4.7 ANOVA Results for Sunlight Variations on Number of Eggs Produced

Variance	Sum of Squares	DF.	Mean Square	F	Sig.
Between Groups	323.63	2	161.817	4.371	0.017
Within Groups	2110.100	57	37.99		
Total	2433.73	59			

The result in table 4.7 shows that ‘f calculated = 4.371 and ‘f’’ tabulated = 3.15. Since ‘f’ calculated is greater than ‘f’ tabulated the null hypothesis is rejected while the alternative hypothesis is accepted. Therefore, the variations of sunlight intensity and number of eggs produced is statistically significant. This is a clear indication that there is significant difference between the variation of sunlight intensity and number of eggs produced within the study area.

4.4.2 Test for Sunlight Variations on Weight of Eggs Produced

Analysis Of Variance (ANOVA) statistical technique was employed at 0.05 significant level to test for sunlight variations on weight of eggs produced. The result for hypothesis is presented in Table 4.8

Table 4.8 ANOVA Results for Sunlight Variations on Weight of Eggs Produced

Variance	Sum of Squares	DF.	Mean Square	F	Sig.
Between Groups	4.162	2	2.081	12.671	0.000
Within Groups	9.362	57	0.164		
Total	13.524	59			

The result in table 4.8 shows that ‘f calculated = 12.671 and ‘f’’ tabulated = 3.15. Since ‘f’ calculated is greater than ‘f’ tabulated the null hypothesis is rejected while the alternative hypothesis is accepted. Therefore, the variations of sunlight intensity and weight of eggs produced is statistically significant. This is a clear indication that there is significant difference between the variation of sunlight intensity and weight of eggs produced within the study area.

4.4.3 Test for Sunlight Variations on Number of Cracked Eggs Produced

Analysis Of Variance (ANOVA) statistical technique was employed at 0.05 significant level to test for sunlight variations on number of cracked eggs produced. The results for hypothesis is presented in Table 4.9

Table 4.9 ANOVA Results for Sunlight Variations on Number of Cracked Eggs Produced

Variance	Sum of Squares	DF.	Mean Square	F	Sig.
Between Groups	0.033	2	0.17	0.027	0.973
Within Groups	35.300	57	0.619		
Total	35.333	59			

The result in table 4.9 shows that 'f calculated = 0.027 and 'f'' tabulated = 3.15. Since 'f' calculated is less than 'f' tabulated the null hypothesis is accepted while the alternative hypothesis is rejected. Therefore, the variations of sunlight intensity and number of cracked eggs produced is statistically not significant. This is a clear indication that there is no significant difference between the variation of sunlight intensity and number of cracked eggs produced within the study area.

4.4.4 Overall test on variations of sunlight intensity on combined dependent variables

Overall test on variations of sunlight intensity on combined dependent variables: number of eggs, weight of eggs and number of cracked eggs produced within the study period are represented in table 4.10

Table 4.10: F Test showing the Sunlight variations versus number of eggs, weight and cracked eggs produced

Dependent Variable	F	Sig.	
Number of Eggs produced	4.371	0.017	Sig
Weight of Eggs	12.671	0.000	Sig.
Number of Cracked eggs	0.027	0.973	Not Sig.

However results in table 4.10 shows that the maximum effect of sunlight variation indicates that weight of eggs was found to be the most significantly dependent variable affected by sunlight followed by number of eggs while cracked eggs is not significant as it is not affected by variations in sunlight intensity.

CHAPTER FIVE: DISCUSSION

The Manova test revealed a significant difference between variation in sunlight intensity and number of eggs produced as equally observed. These findings indicate that there was delay in feeding and laying in the early morning hours with low light intensity compared to that of high intensity which could be attributed to the insufficient light received in the early morning and evening times of the day resulting in decreasing daily photoperiod. This is in agreement of these findings of Harrison (1972), Lewis *et al.*, (1992) which showed that decrease in day length (photoperiod) can cause an overall decrease in egg production, also the agreed with the views of Ensminger (1980) who reviewed the historical perspective of the early century poultry farmers in the state of Washington, USA and found that winter production could increase by placing linted lantern in the chicken house for few hours in the evening in order to increase the work day of the bird which confirmed the report the Wagener (1950) that light and heat had stimulating effects on egg production and higher performance.

There was a reduction in number of eggs produced with decrease in light intensity in this study. This was in line with earlier findings of Atanda (1991) who revealed that bigger and more eggs were produced at the better lit area than the darker area. This collaborated the work of Nesheim *et al.*, (1979) who revealed that season had influence on pattern of egg production with increased egg production being favoured by increasing light and vice versa.

On the weight of eggs, the Manova test revealed a significant difference between variation in sunlight intensity and weight of eggs produced. Also the results indicate that there was increase in feed intake and weight of egg with increase in sunlight. This results were in line with the earlier findings of Prescott and Wathes, (2002) on the subject dealing with a strong and active preference for feeding under bright illuminances (200 lux) rather than very dim light (<20 lux). Also it agrees with the findings of Sainbury (1976) who reported that light had great influence on egg production in birds kept intensively under bright illuminances which affected feed consumption, reproduction and behaviour in birds.

The Manova test revealed no significant difference between variations in sunlight intensity and number of cracked eggs produced. Also low number of cracked eggs, less cannibalism and feathery pecking were observed with low light intensity compared to brighter illuminance which agreed with the findings of Prescott and Wathes (2002) who studied pecking and cannibalism in hens (ISA brown) and found a strong and active preference for pecking under bright illuminances (200 lux) rather than very dim light (<1 lux).

The responses as observed in this study indicated that under low intensity, with regards to animal welfare, there was less visibility in terms of inspection of flocks compared to high sunlight intensity. This findings confirmed earlier works of Manser (1996), Martrenchar (1999); Prescott *et al.* (2003) and Morris (1994) on the subject dealing with animal welfare; and works of Appleby *et al.* (1992) on the issues of ensuring adequate inspection of flocks and staff working conditions under adequate light intensity

Equally observed in this study was delay in feeding and laying in the early morning hours with low intensity compared to those of high intensity of light which was in agreement with the findings of SCAHAW (2011) who concluded that brighter lightening stimulates activity and welfare of birds there by increasing the day length on such aspects of metabolism on the onset of breeding activity (Lewis and Morris 1998).

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

This study focused on sunlight light intensity on egg production in Samaru, Zaria for the period of 20 weeks (August – December, 2014). It was carried out to determine the effect of variations in sunlight intensity and chicken egg production in the study area by taking their daily records of eggs and readings on illumination. It also sought to examine the temporal variations in sunlight intensity, using multiple analysis of variance (MANOVA) at 0.05 significant level to examine the effect of sunlight intensity on chicken egg production, in order to determine if there is any relationship between them.

The types of data required were Daily records of eggs and illumination data for 20 weeks (August– December 2014). The source of data was primary, which was obtained from the experimental site of the study area. Data were presented in percentages, tables and Line Graphs. Data were also analyzed using descriptive statistics and inferential statistics. This includes Multiple Analysis of Variance (MANOVA) was statistical tool used in analyzing the data.

The findings signified that the daily mean production percentage and weight of egg was at its peak at high intensity while number of cracked eggs was not significant. Overall findings signify that weight of eggs is the most significant compared to number of eggs and number of cracked eggs with variations in sunlight intensity at 5% Significance level.

6.2 Conclusions

This study has provided insight to Climatic effects on poultry production in Samaru, Zaria, Nigeria.It has also provided the prospect on the necessary precautions that can be taken in order to enhance productivity of poultry in the area as well as assisting other policy makers in their decisions for effective poultry managements.. The result of this study shows that light environment has effect on laying hens via many different routes of egg production. The study observed that dispersion is lower with higher sunlight intensity in terms of quantity and weight of eggs with no significant difference in the amount of cracked eggs. However the high luminance recorded superiority over the low illuminance, resulting in more eggs being laid in high illluminance. There was weak relationship between sunlight intensity and number of egg produced, while a strong relationship between sunlight and weight of egg produced when subjected to higher luminance with no significance in the amount of cracked eggs.

6.3 Recommendations

Based on the findings of the study, it is recommended thus:
Poultry farmers should;

a. There is need for poultry farmers especially in the tropics to allow more light by increasing the illumination from the present minimum recommended 5 lux to a minimum of 200 lux and above. Preferably this should be combined with more open sides and transparent roof devices for wider span husbandry.
b. For existing husbandries, there is a need to improve the light intensity by adjusting the 0.9m standard side walls to less than 0.3m height and wire mesh not less than 2m height to throw in more light into the pens.
c. There is also need for the establishment of appropriate housing sanitation practices such as wire mesh, roof light source for continuous penetration of sun light rays.

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APPENDICES

APPENDIX 1

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
VAR00002	1.00	20	110.5000	6.46855	1.44641	107.4726	113.5274	94.00	121.00
	2.00	20	110.3500	6.62749	1.48195	107.2482	113.4518	100.00	124.00
	3.00	20	115.3500	5.02913	1.12455	112.9963	117.7037	104.00	124.00
	Total	60	112.0667	6.42259	.82915	110.4075	113.7258	94.00	124.00
VAR00003	1.00	20	6.9395	.44913	.10043	6.7293	7.1497	5.76	7.43
	2.00	20	7.0355	.39997	.08944	6.8483	7.2227	6.29	7.79
	3.00	20	7.5400	.36201	.08095	7.3706	7.7094	7.04	8.17
	Total	60	7.1717	.47878	.06181	7.0480	7.2953	5.76	8.17
VAR00004	1.00	20	.6500	.74516	.16662	.3013	.9987	.00	2.00
	2.00	20	.6500	.87509	.19568	.2404	1.0596	.00	3.00
	3.00	20	.7000	.73270	.16384	.3571	1.0429	.00	2.00
	Total	60	.6667	.77387	.09991	.4668	.8666	.00	3.00

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
VAR00002	.732	2	57	.486
VAR00003	.095	2	57	.909
VAR00004	.259	2	57	.773

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
VAR00002	Between Groups	323.633	2	161.817	4.371	.017
	Within Groups	2110.100	57	37.019		
	Total	2433.733	59			
VAR00003	Between Groups	4.162	2	2.081	12.671	.000
	Within Groups	9.362	57	.164		
	Total	13.524	59			
VAR00004	Between Groups	.033	2	.017	.027	.973
	Within Groups	35.300	57	.619		
	Total	35.333	59			

Post Hoc Tests

Multiple Comparisons

Dependent Variable		(I) VAR00001	(J) VAR00001	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
VAR00002	Scheffe	1.00	2.00	.15000	1.92404	.997	-4.6861	4.9861
			3.00	-4.85000*	1.92404	.049	-9.6861	-.0139
		2.00	1.00	-.15000	1.92404	.997	-4.9861	4.6861
			3.00	-5.00000*	1.92404	.041	-9.8361	-.1639
		3.00	1.00	4.85000*	1.92404	.049	.0139	9.6861
			2.00	5.00000*	1.92404	.041	.1639	9.8361
	Bonferroni	1.00	2.00	.15000	1.92404	1.000	-4.5960	4.8960
			3.00	-4.85000*	1.92404	.044	-9.5960	-.1040
		2.00	1.00	-.15000	1.92404	1.000	-4.8960	4.5960
			3.00	-5.00000*	1.92404	.036	-9.7460	-.2540
		3.00	1.00	4.85000*	1.92404	.044	.1040	9.5960
			2.00	5.00000*	1.92404	.036	.2540	9.7460
VAR00003	Scheffe	1.00	2.00	-.09600	.12816	.756	-.4181	.2261
			3.00	-.60050*	.12816	.000	-.9226	-.2784
		2.00	1.00	.09600	.12816	.756	-.2261	.4181
			3.00	-.50450*	.12816	.001	-.8266	-.1824
		3.00	1.00	.60050*	.12816	.000	.2784	.9226
			2.00	.50450*	.12816	.001	.1824	.8266
	Bonferroni	1.00	2.00	-.09600	.12816	1.000	-.4121	.2201
			3.00	-.60050*	.12816	.000	-.9166	-.2844
		2.00	1.00	.09600	.12816	1.000	-.2201	.4121
			3.00	-.50450*	.12816	.001	-.8206	-.1884
		3.00	1.00	.60050*	.12816	.000	.2844	.9166
			2.00	.50450*	.12816	.001	.1884	.8206
VAR00004	Scheffe	1.00	2.00	.00000	.24886	1.000	-.6255	.6255
			3.00	-.05000	.24886	.980	-.6755	.5755
		2.00	1.00	.00000	.24886	1.000	-.6255	.6255
			3.00	-.05000	.24886	.980	-.6755	.5755
		3.00	1.00	.05000	.24886	.980	-.5755	.6755
			2.00	.05000	.24886	.980	-.5755	.6755
	Bonferroni	1.00	2.00	.00000	.24886	1.000	-.6139	.6139
			3.00	-.05000	.24886	1.000	-.6639	.5639
		2.00	1.00	.00000	.24886	1.000	-.6139	.6139
			3.00	-.05000	.24886	1.000	-.6639	.5639
		3.00	1.00	.05000	.24886	1.000	-.5639	.6639
			2.00	.05000	.24886	1.000	-.5639	.6639

*. The mean difference is significant at the 0.05 level.

Oneway

Homogeneous Subsets

VAR00002

	VAR00001	N	Subset for alpha = 0.05	
			1	2
Duncan[a]	2.00	20	110.3500	
	1.00	20	110.5000	
	3.00	20		115.3500
	Sig.		.938	1.000
Scheffe[a]	2.00	20	110.3500	
	1.00	20	110.5000	
	3.00	20		115.3500
	Sig.		.997	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 20.000

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VAR00003

	VAR00001	N	Subset for alpha = 0.05	
			1	2
Duncan[a]	1.00	20	6.9395	
	2.00	20	7.0355	
	3.00	20		7.5400
	Sig.		.457	1.000
Scheffe[a]	1.00	20	6.9395	
	2.00	20	7.0355	
	3.00	20		7.5400
	Sig.		.756	1.000

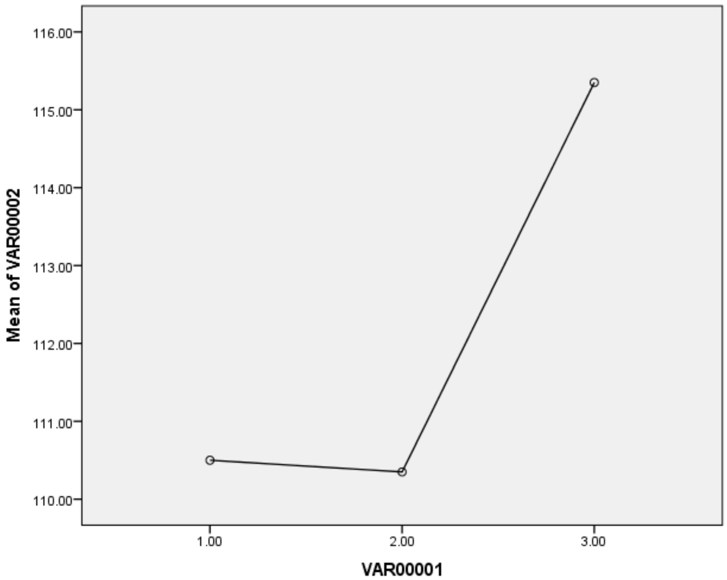
Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 20.000.

VAR00004

	VAR00001	N	Subset for alpha = 0.05
			1
Duncan[a]	1.00	20	.6500
	2.00	20	.6500
	3.00	20	.7000
	Sig.		.852
Scheffe[a]	1.00	20	.6500
	2.00	20	.6500
	3.00	20	.7000
	Sig.		.980

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 20.000.

Means Plots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110.00
Mean of VAR00002
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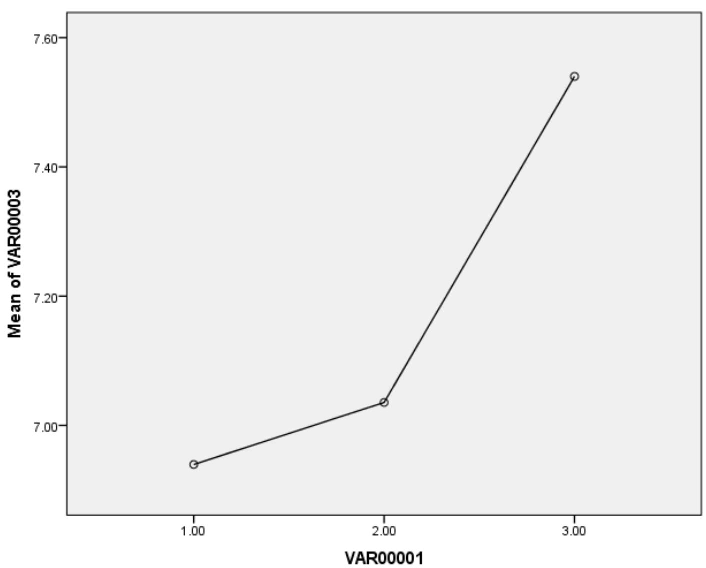
2.00
3.00
VAR00001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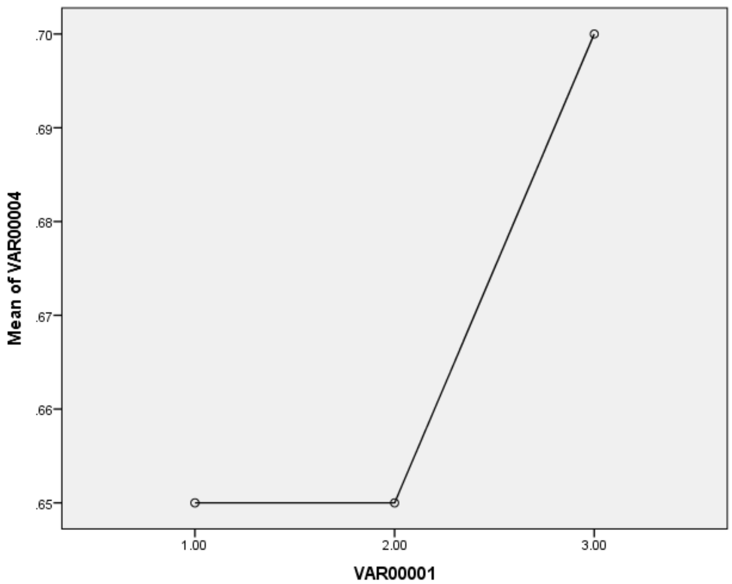
VAR00001



Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
VAR00002	1.00	20	110.5000	6.46855	1.44641	107.4726	113.5274	94.00	121.00
	2.00	20	110.3500	6.62749	1.48195	107.2482	113.4518	100.00	124.00
	3.00	20	115.3500	5.02913	1.12455	112.9963	117.7037	104.00	124.00
	Total	60	112.0667	6.42259	.82915	110.4075	113.7258	94.00	124.00
VAR00003	1.00	20	6.9395	.44913	.10043	6.7293	7.1497	5.76	7.43
	2.00	20	7.0355	.39997	.08944	6.8483	7.2227	6.29	7.79
	3.00	20	7.5400	.36201	.08095	7.3706	7.7094	7.04	8.17
	Total	60	7.1717	.47878	.06181	7.0480	7.2953	5.76	8.17
VAR00004	1.00	20	.6500	.74516	.16662	.3013	.9987	.00	2.00
	2.00	20	.6500	.87509	.19568	.2404	1.0596	.00	3.00
	3.00	20	.7000	.73270	.16384	.3571	1.0429	.00	2.00
	Total	60	.6667	.77387	.09991	.4668	.8666	.00	3.00

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
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VAR00004	.259	2	57	.773

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	Total	35.333	59			

Post Hoc Tests

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		2.00	1.00	-.15000	1.92404	.997	-4.9861	4.6861
			3.00	-5.00000*	1.92404	.041	-9.8361	-.1639
		3.00	1.00	4.85000*	1.92404	.049	.0139	9.6861
			2.00	5.00000*	1.92404	.041	.1639	9.8361
	Bonferroni	1.00	2.00	.15000	1.92404	1.000	-4.5960	4.8960
			3.00	-4.85000*	1.92404	.044	-9.5960	-.1040
		2.00	1.00	-.15000	1.92404	1.000	-4.8960	4.5960
			3.00	-5.00000*	1.92404	.036	-9.7460	-.2540
		3.00	1.00	4.85000*	1.92404	.044	.1040	9.5960
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			3.00	-.50450*	.12816	.001	-.8266	-.1824
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			3.00	-.60050*	.12816	.000	-.9166	-.2844
		2.00	1.00	.09600	.12816	1.000	-.2201	.4121
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VAR00004	Scheffe	1.00	2.00	.00000	.24886	1.000	-.6255	.6255
			3.00	-.05000	.24886	.980	-.6755	.5755
		2.00	1.00	.00000	.24886	1.000	-.6255	.6255
			3.00	-.05000	.24886	.980	-.6755	.5755
		3.00	1.00	.05000	.24886	.980	-.5755	.6755
			2.00	.05000	.24886	.980	-.5755	.6755
	Bonferroni	1.00	2.00	.00000	.24886	1.000	-.6139	.6139
			3.00	-.05000	.24886	1.000	-.6639	.5639
		2.00	1.00	.00000	.24886	1.000	-.6139	.6139
			3.00	-.05000	.24886	1.000	-.6639	.5639
		3.00	1.00	.05000	.24886	1.000	-.5639	.6639
			2.00	.05000	.24886	1.000	-.5639	.6639

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

VAR00002

	VAR00001	N	Subset for alpha = 0.05	
			1	2
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	1.00	20	110.5000	
	3.00	20		115.3500
	Sig.		.938	1.000
Scheffe[a]	2.00	20	110.3500	
	1.00	20	110.5000	
	3.00	20		115.3500
	Sig.		.997	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 20.000.

VAR00003

	VAR00001	N	Subset for alpha = 0.05	
			1	2
Duncan[a]	1.00	20	6.9395	
	2.00	20	7.0355	
	3.00	20		7.5400
	Sig.		.457	1.000
Scheffe[a]	1.00	20	6.9395	
	2.00	20	7.0355	
	3.00	20		7.5400
	Sig.		.756	1.000

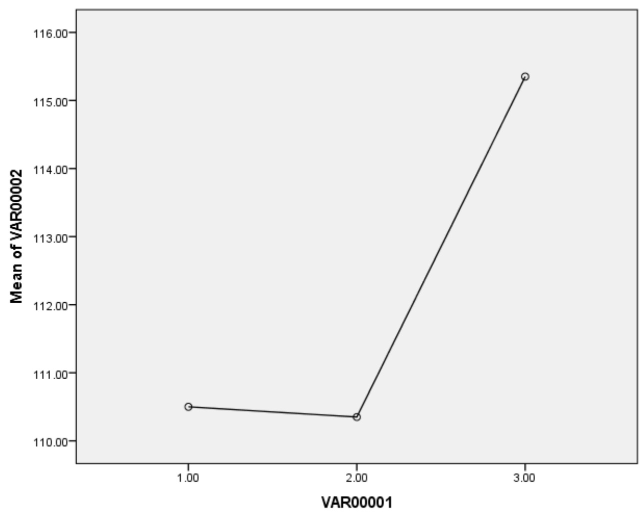
Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 20.000.

VAR00004

	VAR00001	N	Subset for alpha = 0.05
			1
Duncan[a]	1.00	20	.6500
	2.00	20	.6500
	3.00	20	.7000
	Sig.		.852
Scheffe[a]	1.00	20	.6500
	2.00	20	.6500
	3.00	20	.7000
	Sig.		.980

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 20.000.

Means Plots



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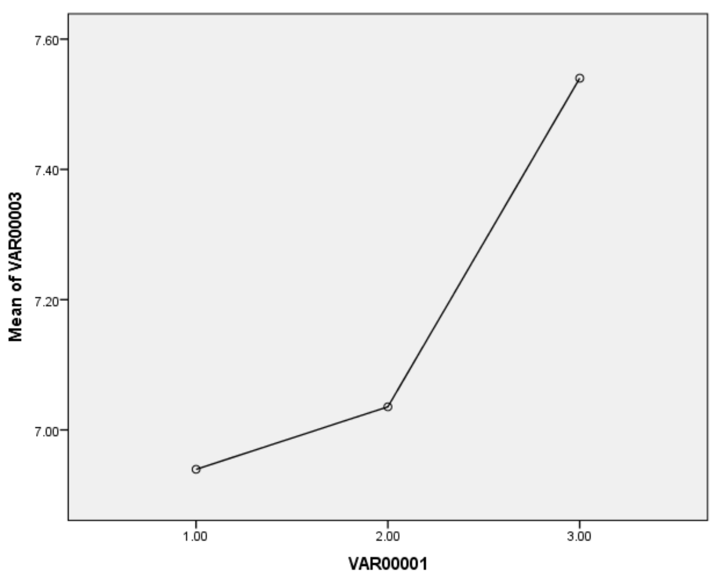
114.00
113.00
112.00
111.00
110.00
Mean of VAR00002
1.00
2.00
3.00
VAR00001



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Mean of VAR00003
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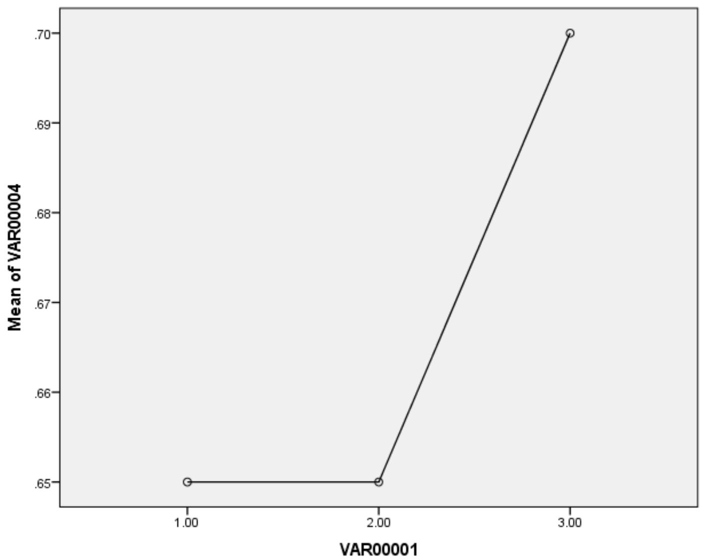
VAR00001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Mean of VAR00004
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VAR00001