ESTIMATION OF GENETIC PARAMETERS FOR SEMEN CHARACTERISTICS IN RHODE ISLAND RED AND WHITE CHICKENS

BY

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DECLARATION

I declare that the work in this thesis entitled 'Estimation of genetic parameters for semen characteristics in Rhode Island red and white chickens' has been performed by me in the Department of Animal Science under the supervision of Drs. O.O.Oni and G.N. Akpa.

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

_____	_____	_____
Name of student	Signature	Date

CERTIFICATION

This thesis entitled "ESTIMATION OF GENETIC PARAMETERS FOR SEMEN CHARACTERISTICS IN RHODE ISLAND RED AND WHITE CHICKEN" by Mohammed Kabir, meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the **Almighty Allah** the Creator of Heavens and Earth.

And to my dearly-loved aged parents: Mallam Mohammad Kyari and Hajiya Maryam Ibrahim (Inna), in grateful recognition of their love, caring, encouragements, prayers, moral and financial support during the course of my Masters Degree Programme.

And to my beloved wife, Hadiza Tahir, and my precious children: Aishatu Mohammed Kabir, Abba-Tahir Mohammed Kabir, Ibrahim-Anas Mohammed Kabir and Zainab Mohammed Kabir (Baby).

And to the memory of my late Niece, Rabi (Anti), her late husband, and their late daughter; May **Allah** grant them Al-Jannatul-Firdaus, Amen.

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ABSTRACT

Three hundred and sixty-one birds from five hatches at one week apart, comprising one hundred and sixty-six cocks and one hundred and ninety-five hens were

used in this study which was conducted from October 2003 to September 2004. The hens consisting of 85 birds from the male line (strain A) and 110 birds from the female line (strain B) were monitored in individual cage units for egg production up to 280 days of age. Similarly, the cocks which were made up of 73 birds from the male line (strain A) and 93 birds from the female line (strain B) were subjected to semen collection using the massage technique at 20, 25, 30 and 40 weeks of age. The ejaculates were then subjected to both physical and chemical evaluations for semen quality analysis. The parameters considered include body weight, shank length, semen volume, semen colour, semen motility, semen concentration and total sperm output. Results showed that body weight and shank length were consistent with each age period and this applies to both strains (A and B). The mean semen volume and colour did not differ significantly ($P>0.05$) for both strains throughout the experimental period. The mean (±SE) semen motility, sperm concentration and total sperm output at 20 and 40 weeks of age were 73.833±2.725% and 71.755±2.725%; 1.175±0.130x10^9/ml and 1.407±0.105 x10^9/ml; 46.433±7.301 x10^9/ml and 64.105±6.397 x10^9/ml respectively for strain A. Similarly, the values for strain B were 74.605±2.199% and 67.397±2.532%; 1.358±0.094 x10^9/ml and 1.271±0.092 x10^9/ml; 53.250±6.714 x10^9/ml and 52.678±4.812 x10^9/ml respectively. Heritability from sire component of variance for body weight (0.892± 0.731) and shank length (0.505±0.066) at 20 weeks of age were high indicating that these traits are highly heritable. Moderate to high heritability estimates were observed for semen volume, semen colour and sperm motility. Positive genetic correlations between Osborne Index and semen volume (1.059), Osborne Index and semen colour (0.727) as well as Osborne Index and sperm motility (0.256) were also obtained. The genetic correlation between

Osborne Index and semen volume changed not only in magnitude but also in direction in later periods. This work revealed that selection based on Osborne Index had no adverse effect on semen quality traits of Rhode Island breeder cocks.

TABLE OF CONTENT

Title page ……..... i
Declaration ……. ii
Certification ……..... iii
Dedication …….. iv
Acknowledgement …… v
Abstract …….. viii

Table of content …… x List of tables ……..... xiii

Chapter One: Introduction

1.0 Introduction …… 1

Chapter Two: Literature Review

2.0 Origin of domestic animals …… 4
2.1 Animal breeding and domestication …….. 5
2.2 The poultry ……. 6
2.3 Breed ……. 7
2.4 Varieties and lines …….. 8
2.5 Basis of selection …… 9
2.5.1 Tandem selection …… 9
2.5.2 Independent culling levels …….. 10
2.5.3 Selection index …… 10
2.6 Semen production in the cock …… 11
2.6.1 Age at sexual maturity in the cock ……. 12
2.7 Factors affecting semen characteristics …….. 12
2.7.1 Light …… 12
2.7.2 Temperature …… 13
2.7.3 Feeding ……... 13
2.7.4 Seasonal variation …….. 14
2.7.5 Frequency of semen collection ……. 15
2.7.6 Semen collector ……. 15
2.8 Correlation among semen traits …….. 16
2.8.1 Osborne index and semen traits …… 16
2.8.2 Semen volume, motility and total sperm …….. 17
2.8.3 Semen output and body weight ……. 17
2.9 Egg production in the hen ……. 18
2.9.1 Age at sexual maturity in the hen …….. 19

2.9.2 Body weight …….. 20
2.9.3 Shank length ……. 22

Chapter Three: Materials and Methods

3.0 Location of the study ……. 23
3.1 Composition of the stock ……... 23
3.2 Mating arrangement ……... 24
3.3 Hatching procedure …… 25
3.4 Housing and equipment ……. 25
3.5 Management and feeding ……... 26
3.6 Semen collection …… 28
3.7 Semen evaluation and analysis …… 28
3.7.1 Ejaculate volume ……. 28
3.7.2 Ejaculate colour and consistency ……. 29
3.7.3 Sperm motility ……. 29
3.7.4 Sperm concentration …… 29
3.8 Production traits considered …… 30
3.8.1 Traits used for females…… 30
3.8.2 Traits used for the males …….. 30
3.9 Estimation of genetic parameters …… 31

Chapter Four: Results

4.1 Mean performance of different traits …… 35
4.1.1 Body weight and shank length ……. 35
4.1.2 Semen characteristics …… 35
4.2 Heritability of different traits …… 36
4.2.1 Heritability for body weight and shank length ……... 36
4.2.2 Heritability for semen characteristics ……. 36
4.3 Genetic correlation between different traits ……... 37
4.3.1 Correlation between body weights at different ages ……. 37
4.3.2 Correlation between shank lengths at different ages ……. 37

4.3.3 Correlation between body weight and shank length …….. 37
4.3.4 Correlation between sperm concentration and total sperm output 38
4.3.5 Correlation between semen volume and total sperm …….. 38
4.3.6 Correlation between motility and sperm concentration …….. 38
4.4 Correlation between Osborne index and semen traits ……. 39
4.5 Environmental correlation ……... 39

Chapter Five: Discussion

5.1 Mean Performance ……. 51
5.1.1 Body weight and Shank length …… 51
5.1.2 Semen traits ……..…….. 52
5.2 Heritability estimates ……... 53
5.2.1 Body weight and shank length ……..... 53
5.2.2 Semen traits ……. 54
5.3 Genetic correlation …….. 55

Chapter Six: Conclusion and Recommendations

6.1 Conclusion …… 58
6.2 Recommendations…….. 60

References ……. 61

LIST OF TABLES

Table 1: Composition of the stock…….. 24
Table 2: Composition of chick, grower, layer and breeder rations…..…… 27
Table 3 Inoculation schedule for the experimental birds ……... 27
Table 4: Analysis of variance for body weight, shank length and

semen traits at different ages for strain 'A' ……. 40

Table 5: Analysis of variance for body weight, shank length and semen traits at different ages for strain 'B' ……. 41

Table 6: Least square Means (± standard error) for body weight, shank length and semen traits at different ages for strain 'A' …….. 42

Table 7: Least square Means (± standard error) for body weight, shank length and semen traits at different ages for strain 'B' …….. 42

Table 8: Heritability estimates from sire component of variance for various traits for strain 'A' breeder cocks at different ages …… 43

Table 9: Heritability estimates from sire component of variance for various traits for strain 'B' breeder cocks at different ages …… 43

Table 10: Correlation between body weights at different ages for strain A (below diagonal) and strain B (above diagonal) ……..... 44

Table 11: Correlation between shank lengths at different ages for strain A (below diagonal) and strain B (above diagonal) ……... 44

Table 12: Correlation of body weights against shank lengths and semen traits for strain A (below diagonal) and strain B (above diagonal) at 20 weeks 45

Table 13: Correlation of body weights against shank lengths and semen traits for strain A (below diagonal) and strain B (above diagonal) at 25 weeks 45

Table 14: Correlation of body weights against shank lengths and semen traits for strain A (below diagonal) and strain B (above diagonal) at 30 weeks 46

Table 15: Correlation of body weights against shank lengths and semen traits for strain A (below diagonal) and strain B (above diagonal) at 40 weeks 46

Table 16: Correlation between semen volumes at different ages for strain A (below diagonal) and strain B (above diagonal) ……..... 47

Table 17: Correlation between semen colour at different ages for strain A (below diagonal) and strain B (above diagonal) ……..... 47

Table 18: Correlation between semen motility at different ages for strain A (below diagonal) and strain B (above diagonal) ……..... 47

Table 19: Correlation between semen concentration at different ages for strain A (below diagonal) and strain B (above diagonal) ……..... 48

Table 20: Correlation between total sperm output at different ages for strain A (below diagonal) and strain B (above diagonal) ….....48

Table 21: Genetic, phenotypic and environmental correlations between Osborne Index and semen traits for male and female lines at 20 weeks…… 49

Table 22: Genetic, phenotypic and environmental correlations between Osborne Index and semen traits for male and female lines at 25 weeks…….. 49

Table 23: Genetic, phenotypic and environmental correlations between Osborne Index and semen traits for male and female lines at 30 weeks……. 50

Table 24: Genetic, phenotypic and environmental correlations between Osborne Index and semen traits for male and female lines at 40 weeks……. 50

CHAPTER ONE

INTRODUCTION

1.0 INTRODUCTION

Some important economic traits in livestock production are limited to only one sex and therefore are called sex-limited traits or characters. For instance, cocks do not lay eggs neither do bulls produce milk, however such males do possess and transmit genes for these traits to their offspring. From practical point of view, when a polygenic trait is limited to only one sex, it becomes very difficult to locate males carrying superior genes for that trait. This limitation however, precludes reliable means (other than progeny and sib tests) of estimating the corresponding genotype in the opposite sex. Therefore the prediction of the breeding value of the male is obtained from the means of his full-sisters and half-sisters (Liljedhal *et al.* 1979).

Little attention has been devoted to the male's role in improving egg production in the domestic fowl. Semen production and egg production appear to be related (Jones and Lamoreux, 1942; Marks, 1981). This implies that, males can also be selected for traits like egg production on an index value based on the egg production of their full and half-sisters. The Osborne Index selection has been a very effective method for improving egg production in chicken (Johari *et al.* 1991). Similarly, Morgan and Carlson (1968) proposed a formula involving hen size, feed consumption and percent production to suggest an index for hen performance.

Reports regarding association between Osborn index and semen production traits are lacking in literature. Sternova *et al.* (1984) reported a non significant phenotypic correlation between semen volume and egg production of full-sisters. Significantly positive correlation between these traits was reported by Thiyagasundaram *et al.* (1985). Similarly, Johari *et al.* (1991) reported low to medium genetic correlation between

Osborn index and semen appearance, semen motility, semen volume and total sperm per ejaculate.

Part-year records of production are used in poultry breeding and selection to shorten the generation interval (Al-Rawi, 1980). In order to shorten the generation interval from two to one year, egg production to certain fixed age has been taken as the norm in poultry breeding and selection work (Bohren 1970). Part-year records of egg mass as the product of egg number and egg weight were used by Quadeer *et al.* (1977). Furthermore, a number of workers (Bohren 1970; Foster 1981; Boukila *et al.* 1987; Oni *et al.* 1992) have reported a very positive relationship between part-year production and total production. The result of analysis of four breeds over years (Kraszewska-Domananska, 1964) showed that selection on only part records should be 26% more effective per year in improving the annual records, than selection on early annual records. Similarly, Bohren (1970) reported that selection on early partial records either in number of eggs or percent production should be more efficient in increasing annual egg production.

Genetic improvement within the shortest possible time has been the goal for every breeder. Classical approach to the breeding of superior birds is based on phenotypic variations observed among and between groups of such birds. However, phenotypic variation is a function of both genetic and environmental differences.

This study is therefore carried out to determine the genetic and phenotypic relationship between semen characteristics and certain production traits in Rhode Island (Red and White) chickens selected for Part-Year egg production.

The specific objectives are to:

1. determine the relationship between egg production index for cocks and semen characteristics.

2. estimate the genetic parameters (heritability and repeatability) for semen characteristics in breeder cocks.

3. determine the relationship between semen characteristics, body weights and shank length.

4. determine the effect of age of cocks on semen characteristics

CHAPTER TWO
LITERATURE REVIEW

2.0 ORIGIN OF DOMESTIC ANIMALS

The domestication of most animal species took place in pre-historic times. Evidence that they originated from wild animals comes from various fields of science. On

the Archeological bones, we can say not only where and when a given species has been domesticated, but also compare skeletons of long-extinct wild animals, with those of domestic animals. By studying the anatomy and physiology of feral forms and their domestic counterparts, it is possible to establish the degree of similarity and accordingly their biological kinship. Proof of such affinity can be supplied by fertile offspring derived from the mating of the wild with domestic animals.

Janusz and Josef, (1982) reported that such species as dog, swine and goat were domesticated some 9000 years ago. Domestication of the pig, dog, duck and goose is believed to have taken place in South east Asia, whereas that of animals living in herds like the horses, cattle, sheep and goats took place in South west Asia. The turkey was said to have been domesticated in its native Central America, the guinea pig and alpaca in South America. Animals believed to have been domesticated in Africa include the cat, donkey and the guinea fowl (Janusz and Josef,, 1982).

Generally, there is no full agreement on whether a particular domestic species has originated from only one feral species (monophyletic origin) or whether many wild ancestors contributed to their origin (polyphyletic origin). Since the time of Darwin (who developed the theory of evolution), most investigators tended to favour the monophyletic origin of domestication.

2.1 ANIMAL BREEDING AND DOMESTICATION

As wild animals came under the care of man, they found themselves in significantly altered environmental conditions from those in which they had previously lived. The quantity and quality of feed, ways of giving it and the feeding times had

changed, as had the type of shelter from bad weather conditions. The random selection of partners for mating also disappeared. Individual animals responded differently to these altered environmental conditions and where some adapted easily, others were eliminated by natural selection.

Man is able to maintain and breed these animals, and those with new traits are allowed to reproduce for many generations, eventually consolidating the desired traits. The consolidation of these desired traits can said to be enhanced by inbreeding, occurring because of geographical isolation in which individual human clans lived. The formation of new traits was further assisted by crossbreeding animals from different regions, which occurred during migration of people and wars of conquest.

Apart from the science of evolution, significant role in modifying and improving the domesticated animal species was played also by the science of animal management, raising and breeding. The studies of Darwin and later Mendel have laid the foundation of the contemporary science of animal breeding. The advances made in veterinary sciences have gone a long way to ensure that the efforts of breeders are not thwarted by animal diseases.

2.2 THE POULTRY

Olomu (1995) defined poultry to be inclusive of all types of domesticated birds such as chickens, guinea fowls, turkeys, ducks, geese, pea fowls, quails, ostriches, pigeons, pheasants, and other game birds. The wild ancestor of the domestic chicken is *Gallus gallus bankiva*, which is still found in the jungles of Southeast Asia. It has a single comb and is characterized by a light build with males weighing 900–1200g and females

weighing 500–700g (Janusz and Josef,, 1982). They further reported that females lay from 3–13 eggs directly on the ground during laying periods and the chicken possess limited ability to fly from one tree to another.

The ancestor of the turkey is the North-American wild turkey (*Meleagris gallopavo*). It was domesticated in Mexico and brought to Europe around 1530 AD (Janusz and Josef, 1982). Males are lager than females and the feral form differs only slightly from the domestic one, but is more slender and agile.

The domestic duck originated from the Mallard (*Anas platyrhynchos*) which inhabits all Europe, Africa, Asia and North America. It nests in the vegetation surrounding ponds or rivers and is a migrant species, over wintering in warmer climates. Males weigh 1.7–2 kg while females weigh much less. Females lay 6–14 eggs in nests.

The guinea fowl (*Numida meleagris*) can be found wild in Africa and was probably domesticated there. They inhabit areas of thin forest. The origin of European geese goes back to the wild graylag (*Ansercinereus*). The graylag is lighter than the domestic goose but apart from the colour and flight ability, it differs little from the domestic species. The Chinese goose on the other hand, originated from the wild goose (*Cynopsis cygnoides*) which was domesticated in China. The Canadian goose descended from the wild goose (*Branta canadensis*) which lived in North America.

Generally, poultry production especially the local species was identified as a means of ensuring sustainable family income. It can be established with minimum cost and as a side project. Moreover, the birds can fend for themselves on free range without

much care (Sani *et al.* 2000). Poultry keeping is usually embarked upon compared with other livestock practices because it has advantages of requiring comparably small capital, faster return, fastest source to provide animal protein for human consumption and requires less space per unit number (Obioha, 1992).

2.3 BREED

An animal breed is a relatively large group of individuals within a species, which have a common origin and can be distinguished by a narrow variation of specific characteristics which are passed on to offspring within the limit of the same fluctuations. One trait alone is usually insufficient to differentiate between individuals belonging to two breeds. The larger the number of traits considered, the easier it is to determine the breed to which a particular animal belongs.

Description of external features called breed standards exist, and is strictly followed in animal breeding. For instance, some breeders claim that the Leghorn owe their excellent production results to their white plumage and so favour keen selection for egg production by culling birds with plumage colours other than white. The Nigerian local poultry exhibit a wide range of plumage colour (Adebambo *et al.* 1999). Similarly, Nwosu and Omeje (1985) observed that multi-colour variation is as a result of lack of conscious selection or breeding programme directed towards choice of colour. According to Janusz and Josef, (1982) the New Hampshire chicken was developed as a result of many years of selection in the Rhode Island Red chicken.

The necessity of adapting animals to the environment and to man-made requirements has led to the development of many breeds within the same species. For

example, about 120 breeds of cattle are known to exist throughout the world, 65 breeds in horses, 70 breeds in sheep, 45 breeds in swine and 175 breeds in fowl (Janusz and Josef, 1982).

It is assumed that there is only one type of local chicken in Nigeria even though the Hausa and Fulani settlers in Northern Nigeria recognize by name at least fifteen (15) varieties of local chickens (Ibrahim and Abdu, 1992). The Nigerian native chicken constitute 80–92% (Akinwunmi *et al.* 1979) of the 120 million chickens found in the country, with more than 80% reportedly found in the rural household and peri-urban areas (Sonaiya, 2002).

2.4 VARIETIES AND LINES

If a particular breed is distributed over a large area and selection proceeds in different directions in individual regions, considerable differentiation can occur within the breed. Such group of animals having certain common characteristics which distinguish it from other groups within the same breed is called a *variety*. The breed may further be differentiated into subunits of a variety, according to the type of animals related to each other through common prominent ancestors. A *line* is usually formed by a sire. The line started by a dam is known as a family (Janusz and Josef, 1982).

In poultry breeding, large flocks of about 2000 individuals allowed to breed without the influence of 'foreign blood' for at least three generations is termed a *strain*. A group of animals of the same species containing individuals of different sex and age used on one farm is known as a *herd or flock*. All the animals kept on a given farm, irrespective of species are defined collectively as *livestock*.

2.5 BASIS OF SELECTION

Selection is an important tool for changing gene frequencies to better fit individuals of a particular purpose. It is defined as a process in which certain individuals in a population are preferred to others for the production of the next generation.

Selection can be natural or artificial:

Natural Selection is due to natural forces that determine the 'survival of the fittest' in a particular environment. *Artificial Selection* on the other hand, is due to efforts of man to increase the frequency of desirable genes, or combinations of genes in his herd or flock by locating and saving for breeding purposes those individuals with superior performance or which have the ability to produce superior performing offspring when mated together. Concepts of natural and artificial selection, their distinctions as well as other possible procedures have been reported (Nordskorg and Hardiman 1980; Liu *et al.* 1995). Individual selection is usually undertaken using three common methods:

2.5.1 TANDEM SELECTION

Tandem selection is a method practiced for only one trait at a time until satisfactory improvement has been made in this trait, then second trait is selected for some generations and then the next and so on. If there are positive relationships between the characters, then as the first trait improves, the others also improve. But if they are negatively related, then as the first trait improves, the others become worse (Malcolm, 1991). The advantage of this method of selection is only when one or few traits are involved and they are all positively related or are unrelated. The disadvantages of tandem selection include low efficiency and low genetic progress made for the time and effort

expended by the breeder. Since many important traits are negatively related, tandem selection has limited application, (Lasley, 1978)

2.5.2 INDEPENDENT CULLING LEVELS

The task here is to select for all the characters at the same time but independently, rejecting any individual that do not meet the minimum standard for each trait of interest regardless of his values for any other character (Malcolm, 1991). The advantage of this method is when a particular colour or colour pattern is required; e.g in the production of show cattle and in test stations (Lasley, 1978). It also considers more traits at a time than tandem selection.

2.5.3 SELECTION INDEX

Perhaps the best technique for multiple objective selection is the selection index. This method of selection entails separate determination of the value for each trait selected for according to its relative economic importance, its heritability, genetic and phenotypic correlations between the different characters. The values are then added up together to give a total score or index. The animals with the highest total score are then kept for breeding purposes (Malcolm, 1991). Selection index is more efficient than the other two methods discussed above, because it allows those animals that are superior in some traits to be saved for breeding purposes even though they may be slightly deficient in one or more other traits. Its disadvantage is that construction of selection indices is highly complex and requires not only considerable data on each parameter but complex computer assistance in evaluation. Selection indices have been constructed and used by Hazel (1943); Osborne (1957a, b) and Henderson (1963).

2.6 SEMEN PRODUCTION IN THE COCK

The paired testes of the male fowl are situated within the abdomen and are suspended from the dorsal body wall on either side of the midline adjacent to the anterior parts of the kidney and just posterior to the lungs (Lake and Stewart, 1978). Semen consists of spermatozoa and fluid produced within the testes and the duct portion of the genital tract called the ducti deferentes. Semen is stored in the ducti deferentes which end in two papillae projecting into the cloaca (Lake, 1966).

The male fowl has no penis, but an erectile phallus which is believed to make contact with the everted vagina during copulation (Kamar and Hafez, 1975). Erection of the phallus is caused by it becoming engorged with blood as are the related cloacal structures (lympholds).

Semen is the complete generative fluid emitted by the male. It is a suspension of living cells (the spermatozoa) in a colloidal or semi-gelatinous medium known as seminal plasma. The ultimate goal of semen collection is to harvest the maximum number of spermatozoa of the highest possible quality per ejaculation. Quality of semen can be lowered by poor collection procedures.

As in mammals, chicken spermatozoa mature in the epididymis. However, there are no seminal vesicles or Cowper's glands. The testes are without septa and lobules and consist of seminiferous tubules, rete tubules and vas efferentia. There is also relatively less seminal plasma in chicken semen than in mammalian semen (Kamar and Hafez, 1975).

2.6.1 AGE AT SEXUAL MATURITY IN THE COCK

Male fowl is capable of producing small amount of semen at 16 to 20 weeks old (Lake and Stewart, 1978). However, maximum volume of good quality semen may not be obtained until 24 to 32 weeks of age. Omeje and Marire (1990) reported that genotypic differences affected body size and semen characteristics of cocks, while age difference significantly affected variation in body size, pH and semen volume. According to Lee *et al.* (1999), birds aged 21 to 30 weeks which were not earlier trained to ejaculate show less sensitivity to massage thereby proving more difficult in emitting semen. They further concluded that semen at this age has low concentration.

Generally, the age at onset of semen production and the maximum volume of semen obtainable from a male bird depends to some extent upon the breed and strain, age at sexual maturity, the natural season and lighting schedules during rearing (Marini and Goodman, 1969).

2.7 FACTORS AFFECTING SEMEN CHARACTERISTICS

2.7.1 LIGHT

Light of adequate intensity and duration is necessary to maintain good semen production. Lake and Stewart (1978) reported that the light supplied to encourage production in the female is sufficient to allow optimum semen production in the male. In another study to determine the effect of photoperiodicity on semen characteristics of poultry, Bajpai (1963) reported no significant effect of photoperiods on semen volume and total sperm per ejaculate. Egbunike and Nkanga (1999) reported that light, breed and

strain differences exist in semen volume, concentration and total sperm output of naked neck and frizzle egg-type cocks.

2.7.2 TEMPERATURE

Vo *et al.* (1980) reported that high temperatures decreased age at sexual maturity in both male and female egg type birds. They concluded that the fertilizing ability of the cock declines in hot weather. On the other hand, Perek and Snapir (1963) reported that changes in environmental temperatures during an 11 month experimental period had no significant effect on semen volume and sperm concentration in egg-type cocks. The differences they however observed were rather breed dependent. The seasonal variation in semen traits of guinea fowl in Nigeria as reported by Onuora (1982b) was attributed to changes in temperature, rainfall and relative humidity. An elevated body temperature of 41.8 ^{0}C does not affect spermatogenesis in chicken (McDaniel *et al.* 1995), but when the ambient temperature goes up to 43 ^{0}C infertility due to heat stress is not uncommon.

2.7.3 FEEDING

Feed has been implicated by some workers (Hocking and Bernard, 1997; Omeje and Ude, 1998) as one of the factors known to affect semen production and quality in the male bird. Studies by Boone and Hughes (1969) showed that starvation of cocks for isx days led to a marked reduction in semen production, but the condition was reversed after 14 days of resumption of normal feeding. With intensive production and improved feeding, Nwosu (1979) reported a remarkable improvement in the reproductive traits of local chickens. This therefore shows that adequate nutritional environment is essential to maintain the breeding flock in good reproductive condition. Pana *et al.* (2000) reported

that Cornish broiler cocks whose daily feed consumption was limited to 130g produced ejaculates whose concentration did not differ significantly from their full-fed counterparts. According to Ezekwe *et al.* (2003) the effects of underfeeding on semen quality traits appeared to be more severe on the physical rather than biochemical characteristics, which implies that the spermatogenic functions of the testes are more responsive to underfeeding than the secretory activities of the reproductive tract. Dietary crude protein and food intake were reported to affect semen production of broiler breeder males (Hocking and Bernard, 1997). Moderate underfeeding was reported to affect semen production and semen quality attributes of local cocks whereas volume, motility and concentration were significantly depressed by severe underfeeding (Ezekwe *et al.* 2003).

2.7.4 SEASONAL VARIATION

Working on local cocks in Borno state, Bah *et al.* (2001) reported significantly varied semen characteristics during rainy season and found highest sperm concentration in July while volume and total sperm count were highest in August. Seasonal variations in the semen production of Barred Plymouth Rock cocks in Missouri, USA, were demonstrated by Wheeler and Andrews (1943). They showed maximum semen volume in April to May, and sperm concentration being highest during summer. Polge (1951) working in England found that semen volume of White Leghorns reached its peak during November to December period and declined sharply in August. The same author reported that sperm concentration was highest in March and decreased gradually thereafter till September. In another study conducted to determine the effects of season, temperature, humidity and light on semen characteristics of White Leghorn, New Hampshire and Iraqi cockerels, Saeid and Al-Soudi, (1975) found that all semen

characteristics (except pH) were significantly influenced by season. There was also a highly significant monthly and seasonal variation in sperm concentration in all the breeds. They observed maximum concentration during spring and lowest during summer for all the three breeds. Significant positive and negative correlations between climatic factors and semen characteristics in the guinea fowl were reported by Onuora (1982b), and several climatic factors such as temperature, season have been implicated.

2.7.5 FREQUENCY OF SEMEN COLLECTION

Frequency of semen collection may affect semen characteristics as reported by McDaniel and Sexton (1977). They further explained that a 48 hour interval is required for long term collection of semen from chicken though more frequent collection (daily) could be used if semen is to be collected for a short term only so as to avoid exhaustion of the male animal.

2.7.6 SEMEN COLLECTOR

Effect of semen collector on semen volume and sperm concentration in males was studied by Benoff *et al.* (1981). Three semen collectors were used and while the most experienced collector obtained the highest average semen volume with the lowest average sperm concentration, the least experienced collector obtained the smallest average volume though with the greatest average sperm concentration. This suggests that the massaging technique used to ejaculate the males differ among individual collectors. The more experienced person probably exerts a more persistent pressure on the vascular bodies and copulatory organ of the male causing a greater ejection of seminal fluid than the least experienced collector.

2.8 CORRELATION AMONG SEMEN TRAITS

Correlation is the relationship between two matrix characters. It can either be positive or negative. Correlation can be caused by genetic and/or environment. The chief cause of genetic correlation is pleiotropy. However, linkage can also be a cause of transient correlation, particularly in a population derived from crosses between divergent strains. pleiotropy is simply the property of a gene whereby it affects two or more characters. Since semen traits are closely correlated, it is almost difficult to study them separately (Johari *et al.* 1991).

2.8.1 OSBORNE INDEX AND SEMEN TRAITS

In a study conducted to determine the relationship between semen quality traits and Osborne Index values in chicken, Johari *et al.* (1991) reported low to medium genetic correlations between Osborne Index and semen appearance, sperm motility, semen volume and total sperm output. Mymrin *et al.* (1972) and Sternova *et al*, (1984) reported a non-significant phenotypic correlation between semen volume and egg production index of full-sisters, while significantly positive correlation (0.29) between these traits was reported by Thiyagasundaram *et al*, (1985). The dam component genetic correlation between Osborne index and sperm concentration per cc and concentration of live sperm were positive and high in magnitude than sire component (Johari *et al.* 1991). They further suggested the importance of maternal effects for these associations. Osborne index was found to be negatively associated with percent abnormal sperms genetically as well as phenotypically (Johari *et al.* 1991).

2.8.2 SEMEN VOLUME, MOTILITY AND TOTAL SPERM

Significantly positive correlations between sperm motility and sperm concentration were reported by Saeid and Al-Soudi (1975). Bah *et al*. (2001) reported significantly positive correlation between individual motility, volume of semen and total sperm count. Similar positive correlation between semen volume, semen motility and total sperm were reported by Nwagu *et al*. (1996). Medium to high repeatability estimates for poultry sperm head dimensional characteristics were reported by Sinha and Mukherjee (1977). They reported 0.49±0.14cm for sperm head length, .042±0.15 for head area and 0.23±0.15 for head shape, respectively, in White Leghorn cocks. Soller *et al* (1965) reported high heritability and repeatability for all semen variables. High repeatability estimates for parts and organelles of sperm may enhance the success of genetic selection of different strains (Sarkhel and Chakraborty, 1982).

2.8.3 SEMEN OUTPUT AND BODY WEIGHT

Bah *et al.* (2001) and Nwagu *et al.* (1996) observed negative correlation between body weight and sperm output. Other workers (Williams and McGibbon, 1956; Egbunike and Oluyemi, 1979) however reported significantly positive correlation between body weight and semen output. Larger and heavier birds produce relatively greater volume of semen than smaller and lighter birds (Egbunike and Oluyemi, 1979).

2.9 EGG PRODUCTION IN THE HEN

The right ovary and oviduct are rudimentary in the hen and only the left ovary and oviduct are functional. The convoluted oviduct is made up of five distinct areas: the Infundibulum or funnel (9cm long); the Magnum (33cm long); the Isthmus (10cm long); the shell gland or uterus–a pouch-like part of the oviduct which is very thick and

muscular (10-12cm long); the Vagina which leads to the cloaca (12cm long), (Kamar and Hafez, 1975).

The environment in the oviduct is most favourable for spermatozoa when the female is in good laying condition. The most intense layers are the most fertile females. Linked to this, is the well known fact that individual birds at or around the peak of lay produce the most fertile eggs (Kamar and Hafez, 1975). Egg production therefore, is the major index of performance of the layers production. The primary trait normally selected for, in an egg-laying strain of poultry is egg number. Egg weight, body weight and age at sexual maturity are regarded as secondary traits (Kamar and Hafez, 1975).

In describing egg production in the domestic fowl, the criteria used include number of eggs produced to 280 days (termed part-period egg production) and egg number to 500 days (referred to as full-year egg production). Part-period egg production is mostly preferred because it reduces the generation interval by half, consequent upon which the rate of genetic gain is increased. Part year egg production is a combination of age at first egg, rate of egg production and viability; these three traits are highly correlated with part-year egg production. Heritability of egg production is generally low, indicating that variability due to additive gene action such as overdominance, dominance and epistasis may be vital (Kamar and Hafez, 1975).

Oluyemi and Roberts (1979) reported that a chicken will lay for a period of about 365 days. This period is divided into three phases: the first phase is characterized by increase in egg size and body weight and it begins at point of lay and ends about 60-90 days thereafter. Phase II is marked by a gradual fall in production but not in egg size or

body weight and lasts till about 280-294 days. The last phase is made up of the remaining pullet year and terminates in moulting.

2.9.1 AGE AT SEXUAL MATURITY IN THE HEN

According to Hays (1924), age at sexual maturity refers to the number of days after hatching when the first egg was laid. It is the age at which a pullet lays her first egg. Hens that laid their first egg at an early age are more preferred than those who lay theirs at a later age. This is because early maturing birds will produce more number of eggs than late maturing ones. Hays (1924) reported that sexual maturity is determined by at least two dominant genes, one autosomal and the other sex-linked.

In literature, heritability estimates for age at sexual maturity appear to be moderate (approximately 0.38) in both heavy and light breeds, indicating environmental factors playing important roles in the phenotypic expression of the trait. Krishner and Chaudhary (1987) reported heritability estimates of 0.32±0.13, 0.13±0.08 and 0.23± 0.07 for age at sexual maturity, based on the sire, dam and sire plus dam components of variances, respectively.

Abubakar *et al.* (1997) reported heritability estimates for age at sexual maturity of 0.33 and 0.23 for male and female lines respectively. Oni *et al.* (1991) obtained values of 0.373 and 0.224 for age at sexual maturity in two strains of chicken. Kumararaj *et al.* (1991) and Chaudhary *et al.* (1996) gave a range of heritability estimates for age at sexual maturity from 0.19 to 0.87 depending on the genetic group and considered the trait to be low to highly heritable. Pirchner and Krosigk (1973) obtained heritability estimates of

0.38 using sire component of variance and 0.52 using dam component of variance for age at sexual maturity in two strains of White Leghorn.

2.9.2 BODY WEIGHT

The genetic control of growth rate and ultimate body size is based on at least 16 pairs of additive genes (Godfrey, 1953). He further reported that there is a recessive gene (r_g) for small body size located between the S and K loci on the sex chromosome. This gene may be widespread in heterozygous form in normal chickens Due to additive nature of the gene when two breeds are mated together the offspring tend to be intermediate in size.

The estimates of body weight are highly heritable when taken at any given age. Ayorinde *et al* (1988) reported that body weight ranging from 1.7–1.8kg is required for satisfactory performance in guinea fowl. Body weights are shown to be influenced by maternal effect or dominance or both effects, up to maturity as indicated by consistently higher heritability estimates from dam variance component as opposed to those from sire components. Adeyinka *et a.l* (2004) reported moderate heritability for body weights at various ages, but observed high heritability estimates for body weight at 56 days of age and suggested that selection for body weight at this age will improve body weight in subsequent generations. Chambers (1990) observed that heritability for body weight of broilers tends to increase with age.

Abubakar *et al* (1997) reported heritability estimates of 0.26 and 0.16 for body weight at 40 weeks of age for male (strain A) and female (strain B) lines respectively,

Oni *et al.* (1991) reported heritability estimates of 0.413 and 0.044, 0.387 and 0.279 for body weight at 16 and 20 weeks in two strains of chicken.

Prado-Gonzalez *et al* (2003) reported positively low to moderate (0.07 to 0.21) additive direct heritability for 8 and 16 weeks old chickens and explained that low heritability could mean that dominance, epistatic and environmental effects are more important than genetic additive effects on body weight of Creole chicks. Differences in heritability estimates could be attributed to method of estimation, breed, environmental effects and sampling error due to small data set or sample size. Generally, early sexual maturity combined with optimum body weight ensures maximum egg production and egg mass during subsequent part production period (Prado-Gonzalez *et al.*2003).

Heritability estimates of body weight vary from one study to another (Kinney 1969). The heritability estimate of 0.68 was reported by Kolstad (1980). The heritability estimates of body weight at sexual maturity as reported by Krishner and Chaudhary (1987), based on sire, dam and sire plus dam components of variance were 0.78±0.28, 0.40±0.08 and 0.59±0.14, respectively.

Reports on the relationship between body weights at sexual maturity and egg production are conflicting. It appears that every flock has an optimum range of body weight at sexual maturity such that if the average body weight at sexual maturity of the flock falls below the optimum level, its relationship with egg production would be positive. On the other hand, if the average body weight at sexual maturity of the flock

falls beyond the optimum level, then its relationship with egg production would be negative (Krishner and Chaudhary, 1987).

2.9.3 SHANK LENGTH

The bones of the meta-tarsus have been fused and elongated in the chicken to form the shank (Oluyemi and Roberts 1979). The mean value of 7.08cm and 6.89cm shank length for male and female synthetic broilers was reported by Malik *et al.* (1997). Ebangi and Ibe (1994) reported heritability estimate of 0.58±0.12 for shank length. Similarly, Hernandez and Segura (1994) reported 0.51 for shank length respectively. Malik *et al.* (1997) reported heritability estimates of 0.378 and 0.356 in male and female broilers.

Generally, heritability estimates for both body weight and shank length ranges from low to highly heritable (Pirchner and Krosigk, 1973; Kumararaj *et al.* 1991; Chaudhary *et al.* 1996; Malcolm 1991).

CHAPTER THREE
MATERIALS AND METHODS

3.0 LOCATION OF THE STUDY

The study was conducted at the Poultry Breeding Unit of the National Animal Production Research Institute (NAPRI) Shika – Zaria, Nigeria. The area is geographically situated between latitude $11^{o}12'$ N and longitude $7^{o}33'$ E at an altitude of 640 M above sea level (Akpa *et al*. 2002).

Shika is located 22 km northwest of Zaria, and is vegetationally in the northern guinea savannah zone of Nigeria. The climate is characterized by well defined dry and wet seasons. The dry season lasts from mid-October to April and consists of a period of low relative humidity with strong, cold and dry northeast harmattan winds. Thereafter, the hot and dry weather follows with overcastting fine dust particles. The wet season begins in late April/early May and ends in late September/early October. The total annual rainfall ranges from 617 mm to 1365 mm with a 50-year average of 1041 mm. Most of the rains fall between July and September. Temperature records were not available in Shika, however, records from Samaru (about 10 km north-east of Shika) showed that the highest mean maximum screen temperature of 36.8^{0}C occurred in April, while the lowest mean minimum screen temperature of 11.4^{0}C was recorded in December. Mean daily sunshine was about 9.7 hours.

3.1 COMPOSITION OF THE STOCK

The birds used in this study were descendents of the foundation stock imported between February and April 1985. They belong to two strains of egg type chicken each with both sire line (having golden or brown colour) and dam line (which has white or silvery plumage). The stock was composed of a total of three hundred and sixty-one (361) birds from five hatches at one week apart, made up of one hundred and sixty-six (166) cocks as well as one hundred and ninety-five (195) hens. In addition, the cocks comprised of seventy-three (73) from the male line and ninety-three (93) from the female line, while the hens consisted of eighty-five (85) in the male line and one hundred and ten (110) in the female line This gives a total of 158 birds from the male line with 203 from the female line (table 1). A complete description of the foundation stock is as described by Omeje (1987).

Table 1: Composition of the stock

	HATCH NO					
	1	2	3	4	5	**TOTAL**
Cocks						
Male line	18	12	17	19	7	**73**
Female line	14	13	22	28	16	**93**
Hens						
Male line	17	21	16	19	12	**85**
Female line	20	28	26	18	18	**110**
Total birds						
Male line	35	33	33	38	19	**158**
Female line	34	41	48	46	34	**203**
Grand Total	69	74	81	84	53	**361**

3.2 MATING ARRANGEMENT

A total of six pens for each line was used, with each pen housing nine hens. Twelve cocks were selected, six from each line and mated to a total of one hundred and eight females by trapnesting using a mating ratio of 1:9.

Egg collection started two weeks after introduction of the cocks into the pens. Each fertile egg collected was labeled according to the pen number which signifies the sire number, dam identification number and population number. Final recording of eggs laid and mortality was made at the close of each day for every pen.

3.3 HATCHING PROCEDURE

Eggs were collected twice daily from each pen and taken to the hatchery and stored in the Dublino 3TN Tropic Cabinet Egg Cooler having a controlled temperature of 41^0F for seven (7) days. These accumulated eggs were later set into trays and labeled according to their sire number and then fumigated with potassium permanganate (K_2MnO_4) and hydrogen peroxide (H_2O_2), and left for 30 minutes in the fumigation room. They were finally transferred into the incubator having a temperature of 100^0 F. Turning of the eggs was done automatically every hour and they were left there for 18 days. On the 18^{th} day of incubation, eggs were candled to remove infertile ones while fertile eggs were transferred into the hatcher where they remain until day 21. Chicks that hatched out in each compartment on the 21^{st} day were identified using wing band and each was weighed (in grams). All the chicks were given Newcastle disease vaccine intraocularly and Marek's disease vaccine administered subcutaneously at day old. After completing all the procedures in the hatchery, the chicks were then moved to the brooding and rearing house on the farm.

3.4 HOUSING AND EQUIPMENT

On arrival, the day-old chicks were housed at the brooding section in deep litter pens measuring 2.4m x 3.4m with a floor space allowance of 0.074m^2/bird in accordance with the recommendations by Olomu and Offiong (1980). The brooding pens were shielded by polythene sheets, while heat was supplied by means of Kerosene stoves in addition to 100/200 watts electric bulbs. Smaller chick feeders and plastic drinkers were used throughout the brooding period which lasted six weeks. By the end of six weeks, the birds were transferred to the rearing pens in tropical type open-sided buildings. The open sides have dwarf walls (1.2m tall) and finished to the roof with $^3/_4$ inch (19mm) wire mesh. Each pen which measures 3.4m x 3.4m has polythene sheet coverings used for the open sides of the building to protect the young birds from the night and early morning drafts. This lasted from 6–12 weeks of rearing, while sexing was done between 8 and 12 weeks of age. At 18 weeks, the birds were moved to cage-houses where the females were housed in single hen cages measuring 900 cm^2 per bird. The cocks were housed on the deep litter and monitored for semen production until the end of the experimental period.

3.5 MANAGEMENT AND FEEDING

Throughout the experimental period, feed and water were provided to all birds *ad libitum*. From 0–8 weeks of age, chicks were fed chick mash containing 20% CP and 2722 Kcal ME/Kg, from 8–18 weeks a grower ration containing 16% CP and 2737 Kcal ME/Kg was fed and from 18 weeks onward breeder mash was given. The composition of the chick, grower, layer and breeder rations fed to the birds is shown in Table 2. All rations were formulated and mixed at the feed mill of the institute. The feeding regime

was twice daily; between 8:00–9:00am in the morning and between 2:00–4:00pm in the afternoon.

Table 2: Composition of Chick, Grower, Layer and Breeder rations

Ingredients used	Chick Mash	Grower Mash	Layer Mash	Breeder Mash
Maize (%)	45.00	34.50	43.45	43.45
Wheat offal (%)	6.00	15.00	09.00	09.00
Maize offal (%)	10.00	10.00	10.00	10.00
Soya bean cake (%)	20.50	10.45	13.00	13.00
Groundnut cake (%)	13.45	10.00	13.50	13.50
Bone Meal (%)	3.00	3.00	3.00	3.00
Rice offal (%)	0.00	15.00	0.00	0.00
Limestone (%)	1.50	1.50	7.50	7.50
Salt (%)	0.30	0.30	0.30	0.30
Vitamin *Premix (%)	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated Analysis:				
Energy (Kcal ME/Kg)	2722.00	2737.00	2594.00	2594.00
Crude Protein (%)	20.01	15.56	16.60	16.60
Calcium (%)	1.50	1.50	7.50	7.50

[a]**Premix used in this experiment supplied the following per kg of diet:**
Vitamin A (stabilized) 10,0005 iu; Vitamin D_3 (stabilized) 2,250 iu; Vitamin E (stabilized) 5.01 iu; Vitamin K (stabilized) 2.01 mg; Vitamin B_2 4.50mg; Vitamin B_6 3.0mg; Nicotinic acid 22.005mg; Calcium D-Pantothenate 6.0mg; Vitamin B_{12} 0.012mg; Choline chloride 200.10mg; D.O.T (3,5-dinitro-orthotoluamide) 100.05mg; Manganese 80.01mg; Iron 50.01mg; Zinc 40.005mg; Copper 2.4mg Iodine 1.401mg; Cobalt 0.201mg; Selenium 0.051mg.

Routine inoculation and preventive medications were given as indicated in table 3.

Table 3: Inoculation Schedule for the experimental birds

Age of birds	Disease Inoculated Against	Vaccine	Route of Administration
1 (Day old)	Marek's	Marek's disease vaccine	S/C
1 (Day old)	Newcastle	NCDV (Hitchner)	I/O
2 Weeks	Infectious Bursal	IBDV	I/M

2 Weeks	Newcastle	NCDV (Lasota)	Oral in Water
5 Weeks	Gumboro (IBD)	IBDV(Avirulent)	I/M
6 Weeks	Newcastle	NCDV (Kamorov)	I/M
16 Weeks	Newcastle	NCDV (Booster for Layers)	I/M
18 Weeks	Gumboro (IBD)	IBDV (Avirulent) (Booster for laying birds)	I/M

3.6 SEMEN COLLECTION

Prior to the experiment, the cocks were given preliminary training so as to ejaculate and emit semen by the massage technique. In the course of the training, cocks that persistently defecated or urinated and those that do not emit semen were removed from the experiment.

3.7 SEMEN EVALUATION AND ANALYSIS

The essence of semen quality tests is to develop a set of criteria, which can be used to describe semen fertility (Hafez 1987). Semen evaluation involves estimation of both physical and biochemical characteristics of the ejaculate and the procedure for evaluation of semen quality traits has been detailed by Singh *et al.* (1987).

The following characteristics were considered in the course of this experiment.

3.7.1 EJACULATE VOLUME

The massage technique described by Lake (1966) was adopted to obtain adequate volume of semen from each bird. While in a sitting position, each bird was held between the legs (knees), then the abdomen was massaged with one hand and simultaneously stroking the lower back and tail feathers with the other hand. This action caused an erection of the copulatory appendages in the cloaca with subsequent expulsion of semen. The semen was collected in a clean, plastic graduated test tube. The volume of the

ejaculate was read (in milliliters) directly from the graduated tube held at eye level and was recorded against the tag number of each bird.

3.7.2 EJACULATE COLOUR AND CONSISTENCY

Further visual assessment was done to determine the colour of semen as creamy, milky or colourless with a score of 3, 2 or 1 respectively.

3.7.3 SPERM MOTILITY

A drop of the ejaculate was put on a glass slide and covered with a cover slip. This was then observed under the microscope at x100 magnification. The result was recorded as a percentage, with 100% score for sperm cells showing progressive forward movement; 50% score for half of the sperm cells showing vigorous motility and 0% for no motile cell observed at all.

3.7.4 SPERM CONCENTRATION

Sperm concentration is the number of spermatozoa contained in 1ml of ejaculate, and it was determined using the Neubauer Haemocytometer (Lake and Stewart, 1978). The freshly collected semen was diluted with buffered normal saline solution. Some of these common solutions include 5% Triphenyl-tetrazolum chloride in physiological saline, 5% chlorozene in physiological saline, 5g $NaHCo_3$ and 1 ml of 35% concentrated formaldehyde made up to 100ml in Physiological Saline. Using the white blood cell pipette, semen was drawn to the mark at the top of the bubble chamber. The preparation were thoroughly mixed by shaking and allowed to settle for 15–30 minutes. This

incubation period increases the accuracy of the count so that all floating sperm cells must have settled down (Lake and Stewart, 1978). As a rule, during counting only those sperm cells that appear within the five-diagonal squares of the chamber were counted using the light microscope at x400 magnification. Those falling outside the chamber were ignored and not counted.

A basic formula (Lake and Stewart, 1978) was then used to estimate the sperm concentration as given below;

Sperm Conc/ml = No. of sperm cells counted x multiplication factor x dilution factor

To obtain sperm concentration per ejaculate, the concentration per ml is multiplied by the volume of the ejaculate.

3.8 PRODUCTION TRAITS CONSIDERED

Records of all the production traits considered in this research work included: -

3.8.1 TRAITS USED FOR FEMALES

Body Weight (kilograms): This was obtained by weighing each hen at 20 and 40 weeks of age.

Age at Sexual Maturity (days): This was obtained by recording the first day of lay of each pullet.

Egg Number: Eggs laid were collected on daily basis up to 280 days. The recording period consisted of age at first egg up to 280 days. Only the records of the surviving hens at 280 days were included in the subsequent analysis.

3.8.2 TRAITS USED FOR THE MALES

Body Weight (kilograms): This was obtained by weighing each cock at 20, 25, 30 and 40 weeks using automatic weighing balance up to 10g accuracy.

Shank Length (cm): The length of the shank was measured from the hock-joint to the base of the three toes by means of a tape rule at 20, 25, 30 and 40 weeks.

Semen Characteristics: The traits used for the semen quality studies were all taken and recorded at 20, 25, 30 and 40 weeks and they include semen volume, semen colour, sperm motility, sperm concentration and total sperm count.

3.9 ESTIMATION OF GENETIC PARAMETERS

Primary records of individual hen production for two generations of selection were used in this study. The females that survived up to 280 days and having records for age at sexual maturity, egg production to 280 days and body weight at 20, 25, 30 and 40 weeks of age were included in the data for analysis. Similarly, only cocks that produced semen were used for the analysis.

HATCH EFFECT ADJUSTMENT

Before estimating the genetic parameters, the effect of hatch on production was estimated. Individual records were converted to deviations from their hatch means, which is a valid and useful procedure for eliminating an extraneous source of environmental variation. The formula used is shown below:

$$\mathbf{F_i = \mu - x_i}$$

Where; $\mathbf{F_i}$ = Correction factor

$\boldsymbol{\mu}$ = Population mean

x_i = Hatch mean.

After which the F_i was subtracted from the individual values in the i^{th} hatch.

Genetic parameters were estimated using the Full Model whereby the variance component was partitioned into those due to Sire, Dam or Environment. The Model fitted

was of the Nested design (Henderson, 1963), in which a sire was mated to several dams with each mating producing several offspring.

The statistical Model used is of the form:

$$\mathbf{Y_{ijk} = \mu + a_i + b_{ij} + e_{ijk}}$$

Where; $\mathbf{Y_{ijk}}$ = the record of the k^{th} progeny of the j^{th} dam mated to i^{th} sire

$\boldsymbol{\mu}$ = the common mean

$\mathbf{a_i}$ = the effect of i^{th} sire

$\mathbf{b_{ij}}$ = the effect of the j^{th} dam mated to i^{th} sire

$\mathbf{e_{ijk}}$ = the uncontrollable environmental and genetic deviations attributable to the individual (all error terms were assumed to be random, normal and independent with expectation equal to zero).

Analysis of Variance:

Source of Variation	df	Sum of Squares	Means of squares	Expected sum of Squares
Between Sires	S–1	SS_S	MS_S	$\sigma^2_W + K_2 \sigma^2_D + K_3 \sigma^2_S$
Between dams within sires	D–S	SS_D	MS_D	$\sigma^2_W + K_2 \sigma^2_D$
Progeny within sires	n.–D	SS_W	MS_W	σ^2_W

S = Number of sires

D = Number of dams

n. = Total number of individuals

K_2 = Number of offspring per dam

K_3 = Number of offspring per sire

The variance component σ^2_S is as a result of different sire groups which are made up of half sibs and therefore the variance component is equivalent to the variance between half sibs. The variance component σ^2_D is derived from differences between dam

groups. These groups are made up of full sibs and therefore the variance component is equivalent to the covariance between full sibs minus the covariance of the sire half sibs group. The variance component σ^2_W contains the remainder of genetic variance and the environmental variance.

The variance component estimates ¼ of the additive genetic variance, $^1/_{16}$ of the additive genetic variance or variance due to sex linkage depending upon the sex and species of the animal under study.

Estimating Variance Components

$$\sigma^2_W = MS_W$$

$$\sigma^2_D = \frac{MS_D - MS_W}{K_2}$$

$$\sigma^2_S = \frac{MS_S - MS_W + K_2 + MS_D}{K_3}$$

$$\sigma^2_T = \sigma^2_S + \sigma^2_D + \sigma^2_W$$

Estimation of Heritability

The corrected data were used to calculate the sire component of variance derived from a one-way random model, using SAS Programme (1996).

The formula is

$$h^2_s = \frac{4 \times \sigma^2_S}{\sigma^2_S + \sigma^2_E}$$ (Falconer, 1989)

Where;

h^2_s = Heritability based on sire variance component

σ^2_S = Sire variance component

σ^2_E = Error variance component

The standard error of heritability was calculated using sampling variance of intra class correlation (Falconer, 1989)

Estimating Correlations

The genetic, phenotypic and environmental correlations between two traits were obtained by a method similar to that used in estimating heritabilities. The general formula for estimating correlation is as given below;

$$r_p = \frac{Cov_{wxy} + Cov_{sxy}}{Var_{wx} + (Var_{sx})(Var_{sy}) + Var_{sy}}$$

Analysis of Covariance

Source of Variation	df	Sum of Cross Products	Mean Sum of Cross Products	Expected sum of Cross Products
Between Sires	S–1	SCPs	MCPs	$Cov_w + KCov_s$
Progeny within sires	n.–S	SCPw	MCPw	Cov_w

Where;

S = Number of sires

n. = Total number of individuals

Estimating Cov_w and Cov_s

$Cov_w = MCP_w$

$$Cov_s = \frac{(MCP_s - MCP_w)}{K}$$

CHAPTER FOUR

RESULTS

4.1 MEAN PERFORMANCE OF DIFFERENT TRAITS

4.1.1 BODY WEIGHT AND SHANK LENGTH

Least square means and standard errors for the traits studied are presented in Tables 6 and 7. The mean body weight for strain A ranged between 1.262±0.044kg at 20 weeks to 2.539±0.025kg at 40 weeks. The analysis of variance (Tables 4 and 5) showed a highly significant difference ($P<0.01$) for this trait across all ages. The mean shank length values obtained for strain A ranged between 10.434±0.145cm at 20 weeks and 12.688±0.063cm at 40 weeks. Result of the analysis of variance revealed highly significant effect at all ages considered for shank length.

For strain B however, the mean body weight values ranged between 1.144±0.054 at 20 weeks to 2.486±0.042 at 40 weeks. The mean shank length for 20 and 40 weeks were 9.735±0.190 and 12.497±0.117, but no significant difference was observed for the trait at these ages. However, significant ($P<0.05$) difference were observed at 25 and 30 weeks respectively.

4.1.2 SEMEN CHARACTERISTICS

The mean semen volume obtained for strain A ranged between 0.390±0.023 to 0.429±0.023, while for strain B it was between 0.364±0.018 to 0.430±0.031. Non

significant age effect on semen volume and semen colour was observed across all ages for both strains. Similarly, semen motility was not affected by age in strain B. But significant ($P<0.05$) age effect on semen motility was observed in strain A at 20, 30 and 40 weeks respectively. Sperm concentration as well as total sperm showed no significant difference at 20 and 25 weeks for strain A, but highly significant ($P<0.01$) difference was observed at 30 weeks for the two traits. Age significantly ($P<0.01$) affected sperm concentration as well as total sperm at 20 and 30 weeks for strain B, while no such differences were observed for birds that were 25 and 40 weeks old.

4.2 HERITABILITY OF DIFFERENT TRAITS

4.2.1 HERITABILITY FOR BODY WEIGHT AND SHANK LENGTH

The heritability estimates for the traits considered in this work are presented in tables 8 and 9. The heritability estimates observed for body weight at 20, 25, and 30 weeks were 0.892±0.731, 0.304±0.548, 0.077±0.388, while the estimates for shank length were 0.505±0.660, 0.066±0.468, 0.630±0.569 and 0.318±0.463 at 20, 25, 30 and 40 weeks respectively for strain A. These estimates showed that as the breeder cocks grew older heritability for body weight tended to decline in magnitude.

4.2.2 HERITABILITY FOR SEMEN CHARACTERISTICS

The heritability estimates for semen volume, semen colour as well as semen motility for strain A, were observed to be high (0.454±0.649, 0.554±0.671 and 0.838±0.723) at 20 weeks of age. The heritability estimates for semen volume decreased (0.454±0.649, 0.334±0.482, 0.166±0.408) with increasing age (20, 30 and 40 weeks) of birds. Similar trend in values was observed for semen colour (0.554±0.671 at 20 weeks,

0.346±0.560 at 25 weeks); semen motility (0.838±0.723 at 20 weeks, 0.326±0.466 at 40 weeks); sperm concentration (1.372±0.735 at 25 weeks, 0.032±0.370 at 30 weeks and 0.018±0.348 at 40 weeks); and total sperm (1.004±0.702 at 25 weeks and 0.296±0.455 at 40 weeks) respectively.

4.3 GENETIC CORRELATION BETWEEN DIFFERENT TRAITS

4.3.1 CORRELATION BETWEEN BODY WEIGHTS AT DIFFERENT AGES

The genetic correlation between body weights at different ages varied in magnitude and direction depending on the age considered. Table 10 showed the genetic correlation of body weights at different ages for strains A and B. Body weight at 20 weeks was found to be positive and highly correlated with body weight at 25 weeks (0.913), 30 weeks (0.839) and 40 weeks (0.731) respectively. Similarly, body weight at 25 weeks was positive and highly correlated with body weight at 30 weeks (0.866) and at 40 weeks (0.732). The correlation coefficient of 0.557 was obtained for body weights at 30 and 40 weeks. Positive and high genetic correlation between body weights at various ages was observed for strain B.

4.3.2 CORRELATION BETWEEN SHANK LENGTHS AT DIFFERENT AGES

Table 11 shows the correlation between shank lengths at different ages with the following coefficients; 0.869, 0.722, and 0.469 at 25, 30 and 40 weeks of age for strain A, while 0.839, 0.750, and 0.578 were obtained at 25, 30 and 40 weeks of age for strain B.

4.3.3 CORRELATION BETWEEN BODY WEIGHT AND SHANK LENGTH

Body weight was found to be positively correlated with shank length at 20 weeks (0.799), 25 weeks (0.764), 30 weeks (0.735) and 40 weeks (0.624) for strain A, while values obtained for strain B were 0.789, 0.733, 0.703 and 0.136 at 20, 25, 30 and 40 weeks respectively (Tables 12-15).

4.3.4 CORRELATION BETWEEN SPERM CONCENTRATION AND TOTAL SPERM OUTPUT

The association between sperm concentration and total sperm was found to be positively high during each age considered. The correlation coefficients were 0.572, 0.712, 0.777 and 0.883 for strain A, while 0.658, 0.036, 0.738 and 0.818 for strain B at 20, 25, 30 and 40 weeks of age (Tables 12-15). Similar coefficient of 0.72 was reported by Nwagu *et al.* (1996) for correlation between these two traits. The result further conforms to the work of Bah *et al.* (2001).

4.3.5 CORRELATION BETWEEN SEMEN VOLUME AND TOTAL SPERM

Positively high correlations were observed for these two traits (Tables 12-15). The correlation coefficients obtained were 0.743, 0.659, 0.403 and 0.733 for strain A. While 0.746, 0.628 and 0.663 for strain B respectively at 20, 30 and 40 weeks of age.

4.3.6 CORRELATION BETWEEN MOTILITY AND SPERM CONCENTRATION

Although semen motility was found to be low, it was positively correlated with sperm concentration at all ages (Tables 12-15). The correlation coefficient for 20, 25, 30 and 40 weeks were 0.150, 0.195, 0.161 and 0.091 respectively for strain A and 0.081, 0.096, 0.070 and 0.176 respectively for strain B. These observations were in line with the findings of Saeid and Al-Soudi (1975) who reported positively low correlations between these two traits.

4.4 CORRELATION BETWEEN OSBORNE INDEX AND SEMEN TRAITS

Genotypic, phenotypic and environmental correlation between Osborne index and semen traits are presented in tables 21–24. The genotypic correlations observed between semen volume and Osborne index for the two strains were positive and highly significant across all ages.

4.5 ENVIRONMENTAL CORRELATION

The environmental correlations obtained for traits studied are presented in tables 21–24. The values obtained for body weight were positive for strain A at 20 weeks (0.279), 25 weeks (0.230) and 30 weeks (0.013) respectively. But the figures were all negative (-0.940, -0.202 and -0.612) for strain B at those ages considered. The environmental correlation observed for shank length for strain A changed drastically both in magnitude and direction (0.607at 20 weeks, 0.161 at 25 weeks, 0.054 at 30 weeks and -0.019 at 40 weeks respectively) over the period of selection. Similarly, positively high environmental correlations were observed

Table 4: Analysis of variance for body weight, shank length and semen traits at different ages for strain 'A' breeder cocks

	20 wks		25 wks		30 wks		40 wks	
	df	**MS**	**df**	**MS**	**df**	**MS**	**df**	**MS**
Body weight								
Source								
Hatch	4	0.374**	4	0.356**	4	0.267**	4	0.184**
Error	68	0.044	68	0.039	68	0.055	68	0.043

Table 5: Analysis of variance for body weight, shank length and semen traits at different ages for strain 'B' broiler cocks

	20 wks		25 wks		30 wks		40 wks	
	df	**MS**	**df**	**MS**	**df**	**MS**	**df**	**MS**
Body weight								
Source								
Hatch	4	0.252**	4	0.198**	4	0.109NS	4	3.235NS
Error	88	0.059	88	0.047	88	0.051	88	5.081
Total	92		92		92		92	

Table 6: Least Square Means (±standard error) for body weight, shank length and semen traits
at different ages for strain 'A' breeder cocks

Traits	20 Weeks	25 Weeks	30 Weeks	40 Weeks	SEM
Body weight (kg)	1.262 ± 0.044[d]	1.601 ± 0.032[c]	2.054 ± 0.029[b]	2.539 ± 0.025[a]	0.212
Shank length (cm)	10.434± 0.145[c]	11.061 ± 0.082[b]	11.717 ± 0.078[b]	12.688 ± 0.063[c]	0.480
Semen Volume (ml)	0.402 ± 0.038[bc]	0.413 ± 0.037[a]	0.390 ± 0.023[b]	0.429 ± 0.023[c]	0.007
Semen colour	2.816 ± 0.119	2.513 ± 0.145	2.539 ± 0.118	2.968 ± 0.111	0.246
Semen motility (%)	73.833 ± 2.441[a]	73.460 ± 2.041[a]	68.948 ± 2.924[d]	71.755 ± 2.725[c]	0.218
Sperm conc. ($x10^9$/ml)	1.175 ± 0.130	1.285 ± 0.095	1.312 ± 0.137	1.407 ± 0.105	0.173
Total sperm ($x10^9$/ml)	46.433 ± 7.301[cd]	52.626 ± 5.729[ad]	48.972 ± 5.607[c]	64.105 ± 6.397[a]	0.218

[A,b,c,d] Mean values in the same row with different superscripts are significantly different (P<0.05)

Table 7: Least Square Means (± standard error) for body weight, shank length and semen traits
at different ages for strain 'B' breeder cocks

Traits	20 Weeks	25 Weeks	30 Weeks	40 Weeks	SEM
Body weight (kg)	1.144 ± 0.054[d]	1.534 ± 0.046[c]	2.010 ± 0.052[b]	2.486 ± 0.042[a]	0.192
Shank length (cm)	9.735 ± 0.190[c]	10.756 ± 0.140[bc]	11.346 ± 0.113[b]	12.497 ± 0.117[a]	0.513
Semen Volume (ml)	0.430 ± 0.031[a]	0.364 ± 0.018[c]	0.373 ± 0.017[c]	0.418 ± 0.018[b]	0.005
Semen colour	2.610 ± 0.105	2.469 ± 0.097	2.495 ± 0.083	2.593 ± 0.101	0.186

Semen motility (%)	74.605 ± 2.199[a]	72.952 ± 1.999[a]	71.068 ± 1.996[ab]	67.397 ± 2.532[b]	2.712
Sperm conc. (x10^9/ml)	1.358 ± 0.094	1.512 ± 0.073	1.447 ± 0.077	1.271 ± 0.092	0.138
Total sperm (x10^9/ml)	53.250 ± 6.714	56.393 ± 5.772	53.809 ± 4.268	52.678 ± 4.812	4.113

[A,b,c,d] Mean values in the same row with different superscripts are significantly different (P<0.05)

Table 8: Heritability estimates from sire component of 42 ıce for various traits for strain 'A' breeder cocks at different ages

Traits	**h^2 ± SE**			
	20 Weeks	**25 Weeks**	**30 Weeks**	**40 Weeks**
Body weight (kg)	0.892±0.731	0.304±0.548	0.077±0.388	NA
Shank length (cm)	0.505±0.660	0.066±0.468	0.630±0.569	0.318±.0463
Semen Volume (ml)	0.454±0.649	NA	0.334±0.482	0.166±0.408
Semen colour	0.554±0.671	0.346±0.560	NA	
Semen motility (%)	0.838±0.723	1.183±0.722	NA	0.326±0.466
Sperm conc. (x10^9/ml)	NA	1.372±0.735	0.032±0.370	0.018±0.348
Total sperm (x10^9/ml)	NA	1.004±0.702	NA	0.296±0.455

NA: Not Available

Table 9: Heritability estimate from sire component of variance for various traits for strain 'B' breeder cocks at different ages

Traits	**h^2 ± SE**			
	20 Weeks	**25 Weeks**	**30 Weeks**	**40 Weeks**
Body weight (kg)	0.200±0.450	0.062±0.307	0.320±0.390	NA
Shank length (cm)	NA	0.176±0.361	0.220±0.345	0.553±0.511

Semen volume (ml)		NA		0.804±0.590	
	0.546±0.481		NA		
Semen colour		NA		0.402±0.456	
	0.262±0.364		0.159±0.354		
Semen motility (%)		NA		NA	
	0.026±0.250		NA		
Sperm conc. ($x10^9$/ml)		NA		1.015±0.641	
0.103±0.289	NA				
Total sperm ($x10^9$/ml)		NA		0.056±0.305	NA
	NA				

NA: Not Available

Table 10: Correlation between **body weights** at different a[illegible] 43 Strain 'A' (below diagonal)
and strain 'B' (above diagonal)

			1	2	
			3	4	
1.	Body weight 20		-	0.857	
	0.759		0.002		
2.	Body weight 25		0.913	-	
0.891		-0.016			
3.	Body weight 30		0.839	0.866	
-		-0.038			
4.	Body weight 40		0.731	0.732	
0.557		-			

Table 11: Correlation between **Shank lengths** at different ages for Strain 'A'
(below diagonal)
and strain 'B' (above diagonal)

			1	2	
			3	4	

1.	Shank length 20	-	0.839	0.750	0.578		
2.	Shank length 25	0.869	-	0.797	0.605		
3.	Shank length 30	0.722	0.804	-	0.723		
4.	Shank length 40	0.469	0.596	0.672	-		

Table 12 Correlation of body weights against shank lengths a[44]nen traits for Strain 'A' (below diagonal)
and strain 'B' (above diagonal) at **20 weeks**

	1	2	3	4	5	6	7
1. Body weight 20	--	0.789	-0.145	0.095	0.162	-0.068	-0.182
2. Shank length 20	0.799	--	-0.076	0.069	0.084	-0.023	-0.192
3. Semen volume 20	-0.032	-0.021	--	0.414	0.120	0.169	0.746
4. Semen colour 20	0.021	-0.246	0.481	--	-0.053	-0.154	0.141
5. Semen motility 20	0.262	0.223	-0.071	0.022	--	0.081	0.241
6. Sperm conc. 20	0.267	0.199	0.016	0.131	0.150	--	0.658
7. Total sperm 20	0.207	0.197	0.743	0.409	-0.006	0.572	--

Table 13: Correlation of body weights against shank lengths and semen traits for Strain 'A' (below diagonal)
and strain 'B' (above diagonal) at **25 weeks**

	1	2	3	4	5	6	7
1. Body weight 25	--	0.733	0.065	-0.067	0.175	-0.000	0.110
2. Shank length 25	0.764	--	0.057	-0.106	-0.067	-0.023	0.026
3. Semen volume 25	0.116	0.135	--	0.246	0.052	-0.113	0.390
4. Semen colour 25	-0.127	-0.041	0.344	--	-0.044	0.056	0.237
5. Semen motility 25	0.153	0.031	-0.201	-0.062	--	0.096	0.013
6. Sperm conc. 25	-0326	-0.241	-0.009	0.208	0.195	--	0.036
7. Total sperm 25	0.002	0.010	0.659	0.366	-0.276	0.712	--

Table 14: Correlation of body weights against shank length 45 semen traits for Strain 'A' (below diagonal)
and strain 'B' (above diagonal) at **30 weeks**

	1	2	3	4	5	6	7
1. Body weight 30	--	0.703	-0.076	0.050	0.117	0.115	0.120
2. Shank length 30	0.735	--	0.007	0.030	0.117	-0.028	0.058
3. Semen volume 30	0.136	0.060	--	0.314	0.250	0.016	0.628
4. Semen colour 30	0.032	0.027	0.292	--	0.021	0.014	0.135

5. Semen motility	30	-0.012	0.198	-0.052	0.168
--	0.070	0.158			
6. Sperm conc.	30	-0.148	-0.208	-0.217	-0.066
0.161	--	0.738			
7. Total sperm	30	-0.147	-0.206	0.403	0.144
0.118	0.777	--			

Table 15: Correlation of body weights against shank lengths and semen traits for Strain 'A' (below diagonal) and strain 'B' (above diagonal) at **40 weeks**

		1	2	3	4
		5	6	7	
1. Body weight	40	--	0.136	0.007	0.064
0.083	-0.055	-0.090			
2. Shank length	40	0.624	--	0.187	0.011
0.116	0.076	0.096			
3. Semen volume	40	-0.121	-0.021	--	0.420
0.062	0.166	0.663			
4. Semen colour	40	0.258	0.207	0.417	--
0.211	0.075	0.334			
5. Semen motility	40	-0.029	0.066	0.066	-0.076
--	0.176	0.162			
6. Sperm conc.	40	0.033	-0.004	0.385	0.111
0.091	--	0.818			
7. Total sperm	40	0.066	-0.026	0.733	0.255
0.075	0.883	--			

Table 16: Correlation between **Semen volumes** at different 46 for Strain 'A' (below diagonal) and strain 'B' (above diagonal)

	1	2	3
	4		

1. Semen volume 20	-	-0.164	-0.083	0.039
2. Semen volume 25	-0.115	-	-0.004	0.041
3. Semen volume 30	0.029	0.078	-	0.003
4. Semen volume 40	0.022	-0.068	-0.067	-

Table 17: Correlation between **Semen colour** at different ages for Strain 'A' (below diagonal) and strain 'B' (above diagonal)

	1	2	3	4
1. Semen colour 20	-	-0.047	-0.062	-0.019
2. Semen colour 25	-0.056	-	0.093	0.132
3. Semen colour 30	-0.259	0.052	-	0.002
4. Semen colour 40	0.036	0.070	0.346	-

Table 18: Correlation between **Semen motility** at different ages for Strain 'A' (below diagonal) and strain 'B' (above diagonal)

	1	2	3	4
1. Semen motility 20	-	-0.003	0.274	-0.029
2. Semen motility 25	-0.057	-	-0.003	0.026
3. Semen motility 30	0.050	-0.082	-	-0.032

4. Semen motility 40	-0.161	-0.112	0.304
-			

Table 19: Correlation between **Semen concentration** at diffe[47]ges for strain 'A' (below diagonal)
and strain 'B' (above diagonal)

	1 4	2	3
1. Sperm conc. 20	-	-0.132	0.192
-0.164			
2. Sperm conc. 25	0.448	-	-0.071
0.025			
3. Sperm conc. 30	-0.059	0.253	-
0.094			
4. Sperm conc. 40	-0.242	-0.086	-0.256
-			

Table 20: Correlation between **Total sperm output** at different ages for strain 'A' (below diagonal)
and strain 'B' (above diagonal)

	1 4	2	3
1. Total sperm 20	-	-0.082	0.104
-0.226			
2. Total sperm 25	0.296	-	0.017
-0.108			
3. Total sperm 30	-0.200	0.211	-
0.062			
4. Total sperm 40	-0.149	-0.000	-0.159
-			

Table 21: Genetic, phenotypic and environmental correlations between Osborne Index
and semen traits for male and female lines at 20 weeks

Traits	Genotypic Correlation (r_g DI)		Phenotypic Correlation (r_p DI)		Environmental Correlation (r_g DI)	
	Strain A	Strain B	Strain A	Strain B		
	Strain A	Strain B				
Body weight (kg)	0.100	1.246	0.032	0.019	0.279	-0.940
Shank length (cm)	NA	0.682	NA	0.232	-0.079	0.607
Semen Volume (ml)	1.059	NA	0.332	0.344	0.858	NA
Semen colour	0.727	NA	0.312	0.205	0.663	NA
Semen motility (%)	NA	0.256	NA	0.084	-0.122	0.555
Sperm conc. (x10^9/ml)	NA	NA	-0.021	0.034	NA	NA
Total sperm (x10^9/ml)	NA	NA	0.156	-0.090	NA	NA

NA: Not Available

Table 22 Genetic, phenotypic and environmental correlations between Osborne Index
and semen traits for male and female lines at 25 weeks

Traits	Genotypic Correlation (r_g DI)		Phenotypic Correlation (r_p DI)		Environmental Correlation (r_g DI)	
	Strain A	Strain B	Strain A	Strain B		
	Strain A	Strain B				

Body weight (kg)	0.305	1.634	0.008	0.265	0.230 -0.202
Shank length (cm)	0.639	1.715	0.061	0.219	0.161 -0.192
Semen Volume (ml)	NA	0.795	0.250	0.386	NA -1.164
Semen colour	0.838	0.558	0.265	0.264	0.514 -0.134
Semen motility (%)	NA	-0.361	NA	-0.216	0.071 0.768
Sperm conc. ($x10^9$/ml)	0.024	0.564	0.035	0.192	-0.018 5.304
Total sperm ($x10^9$/ml)	0.329	1.551	0.145	0.239	-4.627 -0.187

NA: Not Available

Table 23 Genetic, phenotypic and environmental correlations 49 een Osborne Index
and semen traits for male and female lines at 30 weeks

Traits	Genotypic Correlation (r_g DI)		Phenotypic Correlation (r_p DI)		Environmental Correlation (r_g DI)
	Strain A	Strain B	Strain A	Strain B	Strain A Strain B
Body weight (kg)	-0.006	0.906	-0.024	0.235	0.013 -0.612
Shank length (cm)	0.052	1.323	0.026	0.066	0.054 -1.249
Semen Volume (ml)	0.379	-0.351	0.165	-0.193	0.191 0.133
Semen colour	NA	-0.865	0.148	-0.207	NA 0.499
Semen motility (%)	NA	0.683	0.042	0.036	NA -0.142
Sperm conc. ($x10^9$/ml)	-2.015	-0.131	-0.169	-0.138	-0.024 -0.239
Total sperm ($x10^9$/ml)	NA	NA	-0.135	-0.211	NA NA

NA: Not Available

Table 24 Genetic, phenotypic and environmental correlations between Osborne Index

and semen traits for male and female lines at 40 weeks

Traits	Genotypic Correlation (r_g DI)		Phenotypic Correlation (r_p DI)		Environmental Correlation (r_g DI)	
	Strain A	Strain B	Strain A	Strain B		
Body weight (kg)	NA	NA	0.085	0.237	NA	NA
Shank length (cm)	0.000	0.871	0.026	0.054	-0.019	-0.553
Semen Volume (ml)	-0.082	NA	0.030	0.104	0.023	NA
Semen colour	NA	-2.262	0.142	0.044	NA	0.720
Semen motility (%)	NA	0.134	NA	0.064	-0.193	0.062
Sperm conc. ($x10^9$/ml)	-0.957	NA	-0.047	0.099	-0.122	NA
Total sperm ($x10^9$/ml)	0.068	NA	0.039	0.108	0.023	NA

NA: Not Available

CHAPTER FIVE

DISCUSSION

5.1 MEAN PERFORMANCE

The genetic parameters for body weight, shank length, semen volume, semen colour, semen motility, sperm concentration and total sperm at 20, 25, 30 and 40 weeks of age for the male line (strains A) and female line (strain B) were estimated using the sire component of variance. The least square means for all the traits at different ages were also calculated. The small number of birds used in this study was however a limitation to this work.

5.1.1 BODY WEIGHT AND SHANK LENGTH

The mean body weight and shank length observed in this study at all ages for both strains were high and show good performance for all the birds. Verma *et al.* (1979) reported mean shank lengths of 2.67cm, 3.30cm, 4.04cm and 4.95cm at 2, 4, 6 and 8 weeks respectively in a White Leghorn and Rhode Island cross-bred. Working on 6-weeks old broilers, Malik *et al.* (1997) reported mean shank lengths of 7.08cm for cocks and 6.89cm for hens with body weight of 1.57kg in males and 1.02kg in females, respectively. In a similar work, Chhabra *et al.* (1972) reported 7.18cm and 759.42g as mean shank length and body weight in 10 weeks old broiler chickens. The results of this work further agreed with the work of Ansah *et al.* (1980); Ebangi and Ibe (1994); Sharma *et al.* (1996) and Padhi *et al.* (1999).

5.1.2 SEMEN TRAITS

The breeder cocks showed no significant differences ($P>0.05$) in semen volume, semen colour and semen motility for the two strains. The mean values for semen volume obtained in this study were lower than those (0.7–0.8ml) reported by Bajpai (1963); (0.58–0.80ml) reported by Nwagu *et al.* (1996); and (0.48–0.75ml) reported by Lee *et al.* (1999). They were however, higher than the mean values (0.17–0.37ml) reported by Saeid and Al-Soudi (1975); (0.28ml) reported by Bah *et al.* (2001); (0.39ml) reported by Ezekwe *et al.* (2003); as well as (0.24–0.27ml) reported by Ezekwe and Machebe (2004). Differences in the volume of semen observed can be attributed to breed, age and environmental factors

(Ezekwe and Machebe 2004). No much variation was observed in the colour of semen for both strains. The colour of semen collected in this study was milky, and concur well with the observed colour reported by Nwagu *et al.* (1996).

The mean semen motility, semen concentration as well as total sperm observed in this study were in agreement with the values reported by Bajpai (1963); Saeid and Al-Soudi (1975); Nwagu *et al.* (1996); Lee at al., (1999); and Ezekwe and Machebe (2004). Marini and Goodman (1969) reported decline semen concentration as roosters aged. No such decline was observed in this study, a slight non-significant increase in the concentration of semen was rather observed as birds grow older. Generally, the mean performance of birds used in this study for semen characteristics considered was within the acceptable range reported in literature.

5.2 HERITABILITY ESTIMATES

5.2.1 BODY WEIGHT AND SHANK LENGTH

The results of heritability obtained in this study for body weight and shank length showed a decline in estimates as the birds grew older. This trend was supported by the findings of Singh *et al.* (1988) and Prado-Gonzalez *et al.* (2003) who reported similar decreasing heritability values (0.20, 0.21, 0.13 and 0.07) with increasing age of birds (4, 8, 12 and 16 weeks respectively). The observation

however, disagrees with the findings of Chambers (1990) who reported that heritability for body weight of broilers tended to increase with age.

Abubakar *et al.* (1997) reported heritability estimates of 0.26 and 0.16 for body weight at 40 weeks of age for male (strain A) and female (strain B) lines respectively. While Oni *et al.* (1991) reported heritability estimates of 0.413 and 0.044, 0.387 and 0.279 for body weight at 16 and 20 weeks in two strains of Rhode Island chicken. Ebangi and Ibe (1994) reported heritability estimates of 0.41±0.19 for body weight and 0.58±0.12 for shank length at 12 weeks of age. Hernandez and Segura (1994) reported 0.87 for body weight and 0.51 for shank length respectively. Generally, heritability estimates for both body weight and shank length range from low to highly heritable (Pirchner and Krosigk 1973; Kumararaj *et al.* 1991; Chaudhary *et al.* 1996).

Maternal environment affect bird's growth in two stages, namely; the pre-ovipositional maternal effect and the post-ovipositional maternal effect. The post-ovipositional effect can be divided into prehatch (incubation) and post hatch effects. The post hatch maternal influence on chick growth was not important in this study, because all birds were raised independently of their dams. Therefore, the common environmental effects that may possibly affect chick growth are pre-ovipositional maternal components such as egg size, egg weight, shell quality and yolk composition (Aggrey and Cheng, 1993).

5.2.2 SEMEN TRAITS

The estimates of heritability obtained in this study were similar to values reported by Soller *et al.* (1965) for semen volume (0.41), sperm progressive motility (0.87) and sperm concentration (0.46) respectively, which he regarded as sufficiently high. Such high heritability estimates should warrant mass selection for semen quality so as to improve these traits, if this should prove desirable. The heritability estimates for semen volume tended to decrease (0.454±0.649, 0.334±0.482 and 0.166±0.408) with increasing age of birds (20, 30 and 40 weeks). Similarly, high heritability estimates (0.804±0.590 and 0.546±0.481) for semen colour were observed for strain B breeder cocks at 25 and 30 weeks of age. The higher estimates of heritability suggested the more importance of additive gene action playing major role in the inheritance of the trait and hence the mating of the best to best should produce more desirable offspring. A decreasing pattern in the heritability estimates (0.402±0.456, 0.262±0.364 and 0.159±0.354) for strain B breeder cocks were equally observed at 25, 30 and 40 weeks respectively.

Differences in heritability estimates could be attributed to method of estimation, breed, environmental effects and sampling error due to small data or sample size. Environmental (high temperature and humidity) and poor management conditions are known to increase the residual variance and decrease the heritability estimate.

5.3 GENETIC CORRELATION

Clayton and Robertson (1966) reported highly positive genetic correlation (0.84) between body weight at 12 and 20 weeks of age. Oni *et al.* (1991) also reported a highly positive genetic correlation (0.88 and 0.98) between Juvenile

body weight (16 and 20 weeks of age) in two strains of Rhode Island birds. In a similar study, Sani *et al.* (1991) reported coefficient of 0.09 between body weights at 18 and 32 weeks of age.

Reports regarding genetic correlation between shank lengths at different ages were lacking in literature as such comparison was difficult. However, it was evident from these results that selection for shank length can be done at younger age with the expectation that better result shall be obtained than what would be, if selection is to be done at older age.

Chhabra *et al.* (1972) reported similar highly positive correlation (0.8614) for live body weight and shank length at 20 weeks of age. The results of this study was consistent with the findings of other workers; Lerner (1937); Jull and Glazener (1946); To Sovky *et al.* (1975); Verma *et al.* (1979); Krishner and Chaudhary (1987); Reddy *et al.* (1993); Malik *et al.* (1997). The results further supported the assertions of Chhabra *et al.* (1972) that the association between body weights and shank lengths was positively higher in younger birds than in older ones.

Positive genetic correlation obtained in this study between semen volume and total sperm output were similar to the coefficient (r = 0.67) reported by Nwagu *et al.* (1996) as well as the findings of Bah *et al.* (2001), Ezekwe and Machebe (2004).

The genetic correlations between Osborn index and semen traits observed were in agreement with the report of Thiyagasundaram *et al.* (1985) but disagrees

with the findings of Mymrin *et al.* (1972) and Sternova *et al.* (1984) who reported a non significant genotypic correlation between semen volume and Osborne index.

Highly positive genotypic correlation existed between Osborne index and semen volume (1.059); and with semen colour (0.727). The correlation between Osborne index and sperm progressive motility though positive was only moderately higher (0.256). These coefficients were similar, but higher, to values reported by Johari *et al.* (1991) for semen volume (0.160), semen colour (0.120), semen motility (0.210) and semen concentration (0.035). The observed values also agree with reports from other workers such as Poggenpoel and Duckitt (1988) and Brah *et al.* (1991). The higher estimates of genotypic correlation from sire components observed in this study suggested that genotypic correlation between Osborne index and other semen traits is primarily influenced by sex-linked genes. Linkage is the presence in the same chromosome of two non-allelic genes affecting two traits. Instead of segregating and recombining in a random manner in subsequent generations, the genes travel together in the process of oogenesis and spermatogenesis and thus are inherited together.

The relationship that changed drastically over the period of selection was between semen volume and Osborne index, which changed from positive (1.059, 0.379) at 20 and 30 weeks respectively, to negative (-0.082) at 40 weeks. This could probably be attributed to pleiotropic effects of genes as these are the main reasons for genetic correlation and segregation of the pleiotropic genes affecting

both the traits may be responsible for the change in magnitude and/or direction of a genotypic correlation. Simultaneous selection for two traits in opposite direction, which may be as a correlated response in another trait will cause a positive change in the genotypic correlation as the only genes left segregating will be pleitropic ones affecting both traits in the same direction (Lerner 1958). This may result into the change in direction of the correlation after a number of generations of selection. In general, Bohren (1970) suggested that genotypic correlation is more likely to change under selection in comparison to the heritability. To this extent therefore, most of the genotypic and phenotypic correlations between Osborne index and semen quality traits observed in this study were not unfavourable and so the selection of males on such index will not bring about any deterioration in semen quality characteristics.

Malik *et al* (1997) reported similar positively high environmental correlation between body weight and body conformation traits. This suggests that environmental factors such as temperature, humidity, feed and diseases play vital roles on these birds at younger ages but the effect diminishes in magnitude as the birds grow older.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The heritability estimates observed for body weight and shank length in this study decreased with increasing age of birds. This observation disagrees with the reports from some researchers on one hand, and was at par with the findings of other workers on the other. The differences in the observed heritability estimates could be attributed to differences in method of estimation, breed, environmental effects and sampling error due to small data or sample size. In addition, environmental (high temperature and humidity) and poor management conditions are known to increase the residual variance and decrease the heritability estimate.

The observed heritability estimates for semen traits were moderate to high except for values that are not available (NA), probably due to extremely higher estimates which the computer rejected. The estimates were however in agreement with the reported values in literature

The genetic, phenotypic and environmental correlations for all traits considered in this study were also reported and it indicated positive and high correlation between body weights and shank lengths at different ages.

The genotypic and phenotypic correlations between semen traits were positive and higher at younger ages but moderate at older age. This suggests better association among these traits in younger birds; hence selection should be directed towards younger birds for improvement of these traits.

The genetic, phenotypic and environmental correlation between Osborne index and semen quality traits were in agreement with values reported in literature.

The positively high environmental correlation obtained here for various traits suggested that management practices must be improved to reduce the effect of environment (such as feed, temperature etc) on the performance of the breeder cocks.

In conclusion therefore, long legged birds were found to be heavier in both strains A and B at all ages. The highest heritability estimate of body weight was observed at 20 weeks of age in strain A indicating that selection for body weight at this age will improve body weight in subsequent generations. In terms of semen production and quality, the birds used in this work were efficient in optimum sperm cell production with acceptable sperm picture.

Osborne index which has been used (and is still being used) for the selection of cocks based on the performance of their sibs in National Animal Production Research Institute (NAPRI) Shika – Zaria where this research was conducted, showed positive and high correlation with semen traits. This was an

indication that the Osborne index has no disastrous effect on semen quality traits. In addition selection of these birds based on the index for semen traits, especially semen volume and total sperm output, will certainly improve semen out put and yield better fertility in the flock.

Generally, when the heritability of a trait is high, the correlation between phenotype and the genotype of the individuals on the average should also be high and selection on the basis of individual's own phenotype should be effective. High heritability estimates also indicate that additive gene action is important for that trait and the mating of the best to best should produce more desirable offspring. Low heritability estimate on the other hand, tells us that there is low correlation between the genotype and phenotype and that if we use superior individuals for that trait for breeding purposes, the offspring would not be as superior as when the heritability for the trait was high. Therefore, a low heritability estimate is an indication that variations due to additive gene action are probably small. Rather non-additive gene action such as over dominance, dominance and epistasis may be important.

6.2 RECOMMENDATIONS

Based on the findings of this research work, it is hereby recommended that: -

i) Selection for body weight should be done at younger ages as shown by the high heritability estimates obtained at 20 weeks for strain A.

ii) Knowledge about live shank length of birds at a particular age group can be used to predict their body weight at that age or subsequent ages. This is

because of the direct positive bearing which shank length has on body weight observed at all ages.

However, it is finally suggested that more investigation should be carried out to ascertain the effect (s) of season and environmental factor on semen quality traits in both strains A (male line) and B (female line) of Rhode Island birds.

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