GENETIC EVALUATION OF PERFORMANCE AND BLOOD BIOCHEMISTRY IN JAPANESE QUAIL

BY

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(MSc/AGRIC/06331/2010-2011)

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DECLARATION

I hereby declare that this thesis titled "Genetic Evaluation of Performance and Blood Biochemistry in Japanese Quail" has been written by me in the Department of Animal Science, Ahmadu Bello University, Zaria, under the supervision of Dr. (Mrs.) M. Orunmuyi and Dr. M. Kabir. The information derived from the literature has been duly acknowledged in the text and the list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

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Adedayo. T. ADENIYI **Date**

CERTIFICATION

This thesis entitled "Genetic Evaluation of Performance and Blood Biochemistry in Japanese Quail" by **Adedayo Temitope ADENIYI** meets the regulations governing the award of the degree of Master of Science in Animal Science of Ahmadu Bello University, Zaria, Nigeria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the Sovereign Lord-who is my always present help and also to my dear Family.

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ABSTRACT

A study was conducted in a Northern Guinea Savannah region to evaluate the growth, reproductive and blood biochemistry parameters of parents and their offspring in Japanese quail. A total of two hundred and twenty Day-old chicks (DOC) were used in the base generation and six hundred and thirty DOC were used in the first generation. A digital scale of sensitivity (0.01 g) was used to take the weights. The body measurements taken were the 4-week body weight (BW4), 8-week body weight (BW8), overall average growth rate (Agr) and relative growth rate (Rgr). The reproductive parameters studied were the age at sexual maturity (ASM), weight at sexual maturity (WtAsm), egg weight at sexual maturity (EgAsm), average egg weight (Aveg), egg laid at the 11^{th} week of age (Egg11) and the ratio of egg weight to 4-week body weight (EgB4), taken from female quails which were individually housed. In the 6^{th}-week blood biochemistry studied, glucose (Glu) was measured according to Trinder, 1969 while Alkaline-Phosphatase (ALP) was determined according to Kind and King, 1954. For body weight, sexual dimorphism was observed within and across generations. In the base and first generation, the females and males showed no significant ($P>0.01$) difference for BW4 but the females had a significantly ($P<0.01$) higher BW8 than the males. In addition, the base generation had a significantly ($P<0.01$) higher BW4 and BW8 than the first generation. This difference observed in growth parameters had an effect on reproductive performance. The faster growing birds in the base generation were significantly ($P<0.01$) heavier in weight at sexual maturity and had a heavier egg weight but were significantly ($P>0.01$) lower for age at sexual maturity. The study on the blood biochemistry revealed that in each generation, the females and males showed no significant ($P>0.01$) difference for respective blood parameter; however, the first generation had a significantly ($P<0.01$) higher Glu but a significantly ($P>0.01$) lower

ALP when compared to the base generation. The females had a higher coefficient of variation for the blood biochemistry when compared to those of the males in both generations. For this study it was observed that positive phenotypic correlation coefficient exists between growth rate and ASM. Reproductive traits are generally positively correlated while ALP and Glu are negatively correlated. The magnitude of repeatability estimates showed that the growth traits had higher inherent transmission ability than blood biochemistry and reproductive traits.

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CHAPTER ONE

1.0 INTRODUCTION

Japanese quail (*Coturnix coturnix Japonica*) is an important livestock in Nigeria and in many nations. It is being farmed as the smallest avian species for meat and egg production (Panda and Singh, 1990). Its production is favoured because they are generally accepted, requires less time and space, have rapid growth, earlier sexual maturity, greater laying ability, shorter generation interval and resistance to diseases when compared to chickens. These peculiarities of *coturnixs* have facilitated its commercial production and rearing; mainly as meat in Europe, eggs in Japan and are often bred as dual-purpose birds in other Asian countries (Minvielle, 1998). They are also used as laboratory animals for researches (Baumgartner, 1994) and for extensive use in many studies (Kayang *et al*., 2004) such as for growth, selection and breeding. In Nigeria it is used for research purposes and commercially reared mainly for egg production.

Many researchers have focused their genetic studies on improving only economic traits. A broader perspective of improved and efficient genetic study has emerged because selection, breeding and genetic improvement have a marked effect on characteristics of the blood biochemistry; as researchers utilize the biochemical parameters of the blood as markers in livestock species to enhance productivity and reproductive performance (Emmerson, 2003; Nguyen and Tran, 2003). Genetic resources such as serum enzymes, serum proteins and bilirubin have been established as genetic markers in farm animals (Pagot, 1992). Several researches have shown the relationship between poultry birds' performance and some blood parameters, these includes: plasma Alkaline Phosphatase activity in Rhode Island birds (Orunmuyi *et al.*, 2007), the relationship between growth and blood constituents in Japanese quail by Faraht *et al*, (2010), and variation of plasma constituents at different ages of female Japanese quail (Hassan, 2010).

The relationship between blood parameters (Glucose and Alkaline Phosphatase) as it relates to health or diseased conditions, production and reproduction are needed for proper design of breeding and selection study. The methods that can be used to assess genetic relationships are obtained through estimations such as heritability, repeatability and correlation between traits. Heritability of traits is the surest method used to predict the genetic progress obtained (Caron *et al.*, 1990). The higher the heritability of the trait under selection, the faster the genetic progress is. In Japanese quail, the heritability of blood constituents reported by Faraht *et al.* (2010) ranged from 0.45 to 0.51, while that of the body weight was observed to be moderate to high (Kocak *et al*., 1995; Abdel Fattah *et al.,* 2006 and Saatci *et al.,* 2006), varying from 0.3 to 0.72 depending on the birds age.

1.1 Statement of Research Problem

The need for more and location specific research on genetic estimates for observable traits and their underlying blood biochemistry in Japanese quail is crucial and has necessitated the need for this research.

1.2 Justification

In order to breed, select or to improve the performance of these birds, certain baseline information/data are required. This work was therefore designed to evaluate the relationship between the performance and blood biochemical parameters in Japanese quails and hence provide further information regarding some genetic parameters of this bird.

1.3 Hypothesis

Null Hypothesis (Ho). There are no significant variations in growth and biochemical parameters of Japanese Quails on the basis of sex, age and generation.

Alternate Hypothesis (Ha). There are significant variations in growth and biochemical parameters of Japanese Quails on the basis of sex, age and generation.

1.4 Objectives

1. To determine variation in growth and some biochemical parameters in Japanese quail across sexes and generations.
2. To estimate genetic parameters between growth, reproductive and some biochemical parameters in Japanese quail.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Japanese Quail

The Japanese quail belongs to the order *Galiformes*, family *Phasinidae*, genus *Coturnix* and species *japonica*. The scientific designation for Japanese quail is *Coturnix japonica*, different from the common quail "*Coturnix coturnix"* (Thear, 1998; Mizutani, 2003). The first record of wild Japanese quail appeared in the eight century in Japan and these species are found in Japan, Korea, Eastern China, Mongolia and Sakhalin as migrating birds. The plumage color of the wild type is predominately dark cinnamon brown. However, adult female have pale breast feathers that are speckled with dark colored spots. Adult males have uniform dark rusted feathers on the breast and cheek (Mizutani, 2003). This sex differences in plumage color appears about 3 weeks of age. Domesticated Japanese quail retain wild type plumage, although they have a variety of other colorations, including white plumage (Mills *et al*., 1997).

The Japanese quail originally domesticated around the 11th century as a pet song bird (Howes, 1964; Crawford, 1990; Kayang *et al*., 2004), has since gained value as a food animal (Wakasugi, 1984; Kayang *et al*., 2004). Several features accounted for the utility of this bird. First, it has attained economic importance as an agricultural species producing eggs and meat that are enjoyed for their unique flavour (Kayang *et al*., 2004). Egg production is important in Japan and Southeast Asia, while meat is the main product in Europe (Baumgartner, 1994) and are often bred as dual-purpose birds in other Asian countries (Minvielle, 1998). Secondly, the low maintenance cost associated with its small body size (80-300 g) coupled with its rapid growth - enabled quail to be marketed for consumption at 5 - 6 weeks of age; its early sexual maturity - resulting in short generation interval (3-4 generation per year), resistance to diseases and high egg production; rendered it as an excellent laboratory animal (Woodard *et al*., 1973; Baumgartner, 1994; Yalcin *et al*., 1995; Oguz and Minvielle, 2001). It has thus been used extensively in many studies (Kayang *et al*., 2004). Thirdly, Japanese quail is also the smallest avian species farmed for meat and egg production (Baumgartner, 1994).

2.2 Growth Rates in Japanese Quail

Growth is one of the main attributes of living things and is such an obvious process that it hardly seems to justify any particular formal definition. In biology, growth can be defined as the changes throughout life accompanied by the utilization of materials, leading to an increase in volume, size, or shape of an organism (Aggrey, 2002). The simple concept of growth meaning getting bigger is perhaps rather better than many of the complicated attempts to formalize something of such extraordinary complexity (Lawrence and Fowler 1997*)*. The study of growth traits helps in judging the efficiency of management and in determining the optimum managerial practices to maintain the gain at optimum level with least cost, since feed cost decreases with increasing growth rate (Aboul-Seoud, 2008).

Growth traits such as body weight and body weight gain are affected by genetic and non-genetic factors such as genotype, year and season of production, sex, nutrition, adaptability, climatic conditions and management (Hafez, 1963). Improving these environmental influences, choosing the suitable parental age and by improving the animals genotype by selection and/or by cross breeding improves growth (Pelek and

Dikmen, 2006).Specific growth parameters have been summarized for large variety of birds (Ricklefs, 1968), and in particular quails (Mizutani, 2003); thus generating many hypotheses concerning variable growth rates among species. These hypotheses may be classified into three groups. The first implies that variation in growth rates may be related directly to the environment. The next suggests that variation in growth rates represent the effect of parent's ability to feed and satisfy all the young produced. And the last suggests that variations in growth rate are resultants of constraints imposed on anatomy and physiology of the bird (Ricklefs, 1983).

The phenomena of growth is usually measured by observing differences in body weight recorded at different ages and /or in body gain obtained during different growth periods (Cole, 1966). Growth may be represented in various ways such as: absolute growth rate, relative growth rate and cumulative growth rate in time (Bakker, 1974 and Marks, 1980). The simultaneous consideration of both absolute growth rate and relative growth rate gives better information than examining only one of them to compare changes in growth. (Narinc *et al.*, 2010). The absolute growth rate may be defined as the weight increment per unit of time. It can be mathematically presented as;

$$\frac{W_2 - W_1}{T_2 - T_1}$$

Where W_2 = Final weight

W_1 = Initial weight

T_1 = Initial time

T_2 = Final time

In which $W_2 - W_1$ is the weight increment in time interval $T^2 - T_1$.

The relative growth rate as defined by Kizilkaya *et al.* (2006) is the absolute growth rate divided by the actual weight according to the following formula.

$$\frac{W_2 - W_1}{\frac{1}{2}\,(W2 + W1)}$$

Where: W_1 = the weight at the beginning of the period under monitoring.

and W_2 = the weight at the end of the period.

The cumulative growth could be represented by the curve of weight against time and is often described by mathematical growth functions (Narinc *et al.,* 2009). The general shape of the growth curve is a sigmoid form and is generally modelled by Logistic, Gompertz or Bertalanffy growth functions, which summarize the information into a few biologically interpretable parameters (Tzeng and Becker, 1981; Goliomytis *et al*., 2003).

Bakker (1974) reported that growth rate and weight for age are traits that are often estimated in animal production research. With these traits all kinds of influences may be estimated. The Japanese quails have been used widely as a model species in research on poultry breeding and the genetics of growth traits. Several studies investigating and characterizing the growth of Japanese quail under practical and laboratory conditions have been carried out (Aboul-Hassan, 2000; Abdel-Fattah, 2006; Mahmoud, 2006; Ajide 2011; and Adelaja, 2012).

2.3 Body Weight in Japanese Quail

The estimated body weight at hatch (BW_0) is limited due to its small magnitude and the fragility of the neonates. However, Abdel-Fattah (2006) obtained the estimate as 7.05 g for combined sexes, Aboul-Hassan (2000 and 2001a) obtained 8.6 g and 8.3 g respectively in a random bred population; while Marks (1993) and Oguz *et al*. (1996) obtained an estimate of 9.3 g in lines selected for high body weight. Abdel-Tawab (2006) at this age obtained an estimate that ranged between 8.48 and 9.38 g among lines selected for increased egg weight produced among the first 10 weeks of laying.

For two-week body weight (BW_2), Lepore and Marks (1971); Mousa (1993) and Aboul-Hassan (2000) reported an estimate of 43.6, 36.4 and 35.2 g, respectively for combined sexes. Similarly, within this range, El-Fiky (1991) estimated 41.0 and 45.1 g for males and females respectively. Higher estimates were reported by Aboul-Hassan (2001a) as 46.4 g for the Brown strain of Japanese quail and 40.2 g for the White strain for both sexes. Abdel-Fattah (2006) reported higher estimate for this trait as 54.06 and 54.80 g for males and females, respectively.

For four-week body weight (BW_4), Darden and Marks (1988a) reported estimates ranging between 85.3 to 87.3 g for body weight of both sexes in a random bred population of Japanese quail. Furthermore, Mousa (1993) estimated BW_4 as 80.6 g for both sexes. Chahil *et al*. (1975) reported higher estimates for this trait that ranged between 87.3 and 93.5 g for males and 94.5 to 108.2 g for females. Similar estimates were observed by Aboul–Hassan (2000) who reported estimates that ranged between 99.5 and 101.6 g for males and females of Brown strain of Japanese quail and between

82.2 and 84.3 g for males and females of White strain. Furthermore, Aboul-Hassan (2001a) estimated higher BW_4 of Brown and White strains of Japanese quail as 108.1 and 100.9 g for the two sexes respectively, while El-Fiky (1991) found that the means of body weight for both sexes was 107.15 g. Abdel-Fattah (2006) reported much higher estimates for this trait at this age (BW_4) as 127.25 and 132.17 g for males and females, respectively.

At six weeks of age (BW_6), Sefton and Siegel (1974) reported estimates ranging from 100.3 to 102.7 g for males and from 109.8 to 113.1 g for females. Within this range of estimates, Kadry *et al*. (1986) reported an estimate averaged 108.7 g for body weight at 6 weeks for both sexes. Higher estimates of 116 and 135 g were reported by Blohowiak *et al.* (1984) for 6 week body weight of males and female. In this respect, Strong *et al*. (1978) reported an estimate of 126.7 g for BW_6 in females and El–Fiky (1991) estimated BW_6 as 128.1 and 140.8 g for males and females, respectively.

Furthermore, Mousa (1993) reported an estimated average 130.5 g for this trait for the two sexes. Kosba *et al*. (1996) through 5 generations of selection and Aboul-Hassan (1997) through 3 generations of selection estimated BW_6 of selected lines as 164.5, 140.4 g and 151.4, 132.5 g for control lines. However, Aboul-Hassan (2000 and 2001a) estimated BW_6 of Brown strain as 148.1, 140.2 g for males and 154.1, 156.0 g for females, the corresponding estimates for White strain were 144.1, 140.2 g for males and 149.9, 156.0 g for females, respectively. Abdel-Fattah (2006) reported higher estimate for this trait as 171.40 and 182.27 g for males and females, respectively.

Generally, the reported estimates of body weight of Japanese quail recorded at different ages indicate the high efficiency of this bird for growth as reported by Marks (1971); Sefton and Siegel (1974); Darden and Marks (1988a) and Minvielle (2004). The observed differences between these estimates reported for body weight at a particular age may be as a result of differences in climatic conditions, genetic makeup of the flock, degree of managerial activity and selection criteria used.

2.4 Body Weight Gain

Several Researchers have shown the average daily gain (ADG) in Japanese quail maintained under standard nutritional conditions during different growth periods (El-Fiky, 1991; El-Sayed *et al*., 1995; Aboul-Hassan, 2000 and 2001a; Abdel-Tawab 2006 and Abdel-Fattah 2006). Growth rate and weight for age are parameters that are often estimated in animal production research and used as selection trait in many breeding programs (Bakker, 1974). For the $ADG_{0\text{-}2}$ Darden and Marks (1989); El-Fiky (1991); Aboul-Hassan (1997) and Aboul-Seoud (2008) reported an estimate of 2.43, 2.51, 1.66 and 2.17 g/day respectively. In brown strain and white strains at this age, Aboul-Hassan (2000 and 2001a) obtained an estimate of 2.62, 1.91 g/day and 2.06, 1.70 g/day respectively.

At the forth week, Lepore and Marks (1971) and Sefton and Siegel (1974) reported an estimate of 2.40 and 2.34 g/day for the $ADG_{0\text{-}4}$. While El-Fiky (1991) and Aboul-Seoud (2008) obtained $ADG_{0\text{-}6}$ as 3.02 and 3.17 g/day respectively. Furthermore for ADG2-4, El-Fiky (1991) and Aboul-Seoud (2008) obtained 4.57 and 4.96 g/day respectively;

while Aboul-Hassan (2000 and 2001a) estimated 5.82, 5.4 g/day for Brown strain and 5.02, 4.90 g/day for White strain.

The corresponding estimates for the ADG_{2-6} were reported by Lepore and Marks (1971); Sefton and Siegel (1974); Marks (1978); Darden and Marks (1989) and Aboul-Hassan (1997) as 3.21, 3.12, 3.17, 3.57 and 5.02 g/day, respectively. For the ADG_{4-6}, Lepore and Marks (1971); Sefton and Siegel (1974); Marks (1978) and Aboul-Hassan (1997) reported an estimate of 1.36, 1.54, 2.02 and 3.30 g/day. Furthermore, Aboul-Hassan (2000 and 2001a) estimated the ADG_{4-6} among two strains of Japanese quail (Brown and White) as 1.46, 2.30 g/day for Brown strain and 1.12, 2.0 g/day for White strain.

Generally, the reported estimates of body weight of Japanese quail recorded at different ages indicate the high efficiency of this bird for growth (Minvielle, 2004) when compared with chickens or turkey (Wilson *et al*., 1961). Sexual variation in average daily gain exists and the differences were in favor of the females as reported by (Aboul-Hassan, 2001a). When growth rates were compared in male and female Japanese quail, Sefton and Siegel (1974) observed that females have generally higher rate of growth than males and the differences were in favour of females (2.57 vs. 2.46 g/day) during the growth period from 0-2 weeks of age and (3.07 vs. 2.91 g/day) during the growth period from 2-4 weeks of age, while the average daily gain during the growth period from hatch to 6 weeks of age were found to be 2.41 vs 2.17 g/day, respectively. The same trend was observed by Aboul-Hassan (2001a) who found that the average daily gain during the different growth periods studied (ADG_{0-2}, ADG_{2-4}, ADG_{4-6}) were 2.70, 5.30 and 1.50 g/day for females while that for the males were 2.50, 5.00 and 1.30 g/day.

The reported estimates of body weight for males and females Japanese quail at different ages indicate that females are consistently heavier than males (Abdel-Mounsef, 2005; Abdel-Fattah, 2006; Abdel-Tawab, 2006 and Aboul-Seoud, 2008). It seems growth rate of males and females Japanese quail should be considered distinct characteristic of population (Vali, 2008). This matter should be taken into account in any breeding program aimed at improving growth characteristics in Japanese quail.

2.5 Age at Sexual Maturity

In commercial poultry rearing, the index for sexual maturity is attained when 50% of the bird start to lay, however, in breeding research it is very important to estimate the individual birds' age at first egg.

There are numerous reports on the physiologic relationships associated with the onset of sexual maturity in avian females (Koçak *et al*., 1995; Eitan and Soller, 2001; Camci *et al*., 2002; Deyab, 2008). Previous reports have shown that a number of factors contribute to the considerable variability observed in the onset of egg production in chickens, turkeys, and Japanese quail. The variability is thought to be a result of environmental, genetic, and physiologic factors including photoperiod, nutrition, body composition and age of the bird (Brody *et al*., 1980 and 1984; Krapu, 1981 and Asuquo and Okon, 1993). In a Japanese quail line selected for increased 4-wk body weight, differing photoperiods during rearing have been reported to delay the onset of sexual maturity (Nestor, 1985) or not influence it at all (Steigner *et al*., 1992; Anthony *et al*., 1993) compared with a randombred control line.

Age at sexual maturity has been shown to have an effect on egg production traits such as egg number, egg weight, egg mass and body weight at sexual maturity in chickens and quails (Shebl, 1991; Aly, 1992; El-Bodgady *et al*., 1993; Ghanem, 1995; Camci *et al*., 2002 and Meky, 2007). On this estimate, Kadry *et al* (1986); Steigner *et al*. (1989b); Aboul- Hassan and El-Fiky (1990) and Aboul-Hassan *et al*. (1999) estimated the age at first egg in Japanese quail as 49.5, 46.0, 45.4 and 49.8 days, respectively. Marks (1980) studied the age at first egg in Japanese quail during 4 successive generations and found that it ranged between 54.4 and 60.4 days. The lowest estimate for this trait was obtained by Mizutani (2003) who reported an estimate of 38-42 days.

Similarly, in a random bred line of Japanese quail, Steigner *et al.* (1989a) reported an estimate of 42.0 days for this trait. A wider range of values was reported by Inal *et al*. (1996) who observed that quails selected for body weight reached sexual maturity at 39.8–51.1 days of life. The actual mean of days to the first egg laid (age at first egg) was found to be 54.3 and 58.6 days for two strains of Japanese quail (Brown and White) as reported by El-Fiky *et al.* (2000). Within this range of estimates, Sharaf and Mandour (1994) reported an estimate of 53.1 and 56.8 days for age at first egg in Brown and White strains of Japanese quail. Higher estimates for the same trait in Japanese quail were reported by El-Fiky (1994), Shebl *et al.* (1996) and Tawefeuk (2001) which ranged between 55.7 and 64.7 days. Bahie El-Dean *et a*l. (2008) reported age at sexual maturity in Japanese quail females (days) were 42.98, 50.05 and 61.89 for early age at sexual maturity group, medium and late groups; respectively.

Oruwari and Brody (1988) concluded that the interaction between chronological age, body weight, and body composition for the onset of sexual maturity are inseparable. Others have suggested that there are multiple thresholds of minimum chronological age, body weight, and body composition influencing female sexual development (Dunnington and Siegel, 1984; Soller *et al*., 1984; Zelenka *et al*., 1984; Reddish *et al*., 2003).

2.6 Body Weight and Reproductive Traits

Body weight differences during the prebreeding period has been associated with changes in egg production, egg weight, egg number, egg mass and age at sexual maturity in chickens and quails (Aly, 1992; El-Bodgady *et al*., 1993; Ghanem, 1995; Camci *et al*., 2002 and Meky, 2007). In Japanese quails, Kocak *et al*. (1995) observed body weight at onset of sexual maturity at an age of 58.0 days to be 202.2 g. Sreenivasaiah and Joshi (1988) obtained body weight at sexual maturity of 122.9–128.2 g. Sachdev and Ahuja (1986) found that for egg-line females with a body weight of 100-120, 121-140, and 161-180 g at sexual maturity, age at sexual maturity averaged 9, 10 and 11 weeks respectively. Kiling *et al*. (1985) reported that early matured pullets laid their first egg before 136 days, while late pullets matured when they were 152 days of age. Japanese quails are heavier when they reach sexual maturity later, but early sexual maturity reduces the time for the onset of egg production thereby increasing “egg days” production (Nestor *et al*., 2000).

In domestic poultry species, negative correlations between reproductive performance and body weight have been widely reported (Jaap and Muir, 1968; Nestor, 1977; Dunnington and Siegel, 1984 and Marks, 1987). Reproductive performance of broiler breeders decreases as broiler breeders become heavier and fatter (Appleby *et al*., 1994). In turkeys, selection for increased body weight resulted in decreased egg production, intensity of lay, and hatch of fertile eggs (Nestor *et al*., 2000). In Japanese quail, selection for increased body weight under differing nutritional environments resulted in decreased hatchability, egg production and increased abdominal and carcass fat (Marks, 1991). Joyner *et al*. (2004) reported a close positive relationship between age and egg size while a negative relationship exists between the hens age and egg production. Triyuwanta *et al*. (1992) reported that body weight of the progeny at hatching were enhanced by increasing maternal body weight and this positive maternal effect was still present at 40 days of age in dwarf broilers. Similarly, Yalçın *et al*. (1993) observed that females' body weight have an effect on body weight of broilers at hatch, 5, 6, and 7 weeks of age. Also, Yalçin *et al*. (1995) found that hatch weight of Japanese quail increased with increasing the maternal body weight.

2.7 Egg Production

It is well known that egg mass increases as parental hen flock ages and incubated chick mass gets to its maximum at the end of the laying cycle in broiler (Danilov, 2000; Barnett *et al.,* 2004; Maiorka *et al*., 2004 and Hamidu *et al*., 2007). Although egg size and production can be influenced by a number of factors such as improved breeding, increased body weight, composition of feed and nutrition plan, intensity and duration of light; a major factor determining egg size is the age of the bird (Asuquo and Okon, 1993). A close positive relationship exists between age and egg size while a negative relationship exists between the hens age and egg production (Joyner *et al*., 2004). They observed that as the birds advanced in age, the egg production decreased.

The average egg weight of a laying flock increases as the birds get older mainly due to physical and physiological changes (Oluyemi and Roberts, 1979). Furthermore, hen's age have a constant and significant effect on proportion of egg weight, length and width of the eggs, yolk, egg white and egg shell in total egg mass; similarly Haugh unit, yolk, albumen weight and height increased significantly with age of the bird (Rossi and Pompei, 1995; Danilov, 2000; Luquetti *et al.*, 2004; Akpa *et al*., 2006 and Egahi *et al*., 2011). Furthermore there is an increase in repeatability of egg quality traits with linear increase in age of laying Japanese quails (Akpa *et al*., 2008).

For egg weight estimates, Kohler (1981) reported egg weight of 9.1 to 10.9 g in a selection experiment for improving this trait. Asasi and Jaafar (2000) reported that values for egg weight ranged between 9.76 and 11.63 g. Higher estimates for egg weight were reported by Sharaf (1992 and 1996); El-Sayed *et al*. (1993); Inal *et al*. (1996); Bahie El-Deen *et al*. (1998); Ali *et al*. (2002) Abdel-Azeem (2005) and Abdel-Tawab (2006) ranging from 10.00 to 11.86 g. Furthermore, Inal *et al*. (1996) and Aboul-Seoud (2008) gave higher values for egg weight which ranged between 10.94 and 13.23 g among divergent selection experiment for body weight at 5 weeks of age in five generations.

Environmental factors have been shown to have or not to have great effect on egg production. Faqi *et al*. (1997) reported that egg weight was reduced at higher ambient temperature. Gilbert (1980) observed that temperatures between 13 ^{o}C and 21 ^{o}C are recommended for optimal egg production. Egg production is highest when temperatures are within neutrality range (Smith, 1990). The maximum temperature associated with satisfactory laying performance of hens is approximately 30 ^{o}C at a high relative humidity of 75% (Daghir, 1995). Consequently, Munir and Mohammed (2010) reported that ambient temperatures above 30 ^{o}C are considered to have detrimental effect on the performance of laying Quail hens while Vo *et al*. (1980) found that the increase of ambient temperature from 21 to 35 °C decreased egg weight, egg number and egg production percent in single comb Leghorn. Prabakaran (1992) reported that egg weight was not affected by season, but henday egg production of Japanese quail at 13 to 24 weeks of age during summer was lower than in other seasons.

Generally, it is well accepted that the main consequences of heat stress is the reduction in feed intake which reduces metabolic heat production (May and Lot, 1992) leading to poor growth rate, low rate of egg production, reduced feed efficiency, immune-suppression and enhanced fat deposition due to hypothyroid activity (Geraert *et al.,* 1996; Mashaly *et al.*, 2004; Quinteiro *et al.*, 2010). To reduce the deleterious effects of heat stress so as to enhance egg production, many practical approaches have been developed to facilitate thermo-tolerance of birds which minimizes the adverse effects heat stress has on productivity. These approaches include pre and / or post acclimation of birds (Abd El-Azim, 1991 and Arjona, 1998), use of some electrolytes and vitamins (Cftc *et al.,* 2005) and dietary energy or lysine manipulation (Belnave and Brake, 2005; Gous and Morris, 2005).

2.8 Fertility Percent in Japanese Quail

Fertility is one of the most important reproductive traits in Japanese quail; it is the proportion of eggs that are capable of developing into chicks out of the number laid and incubated. It is affected by different factors such as genetic, physiological, social and environmental factors (Islam *et al.,* 2002). The fertility of an egg is also affected by both the sire and dam. The hen factors includes her ability to mate successfully, the store of sperm, ovulation rate and availability of a suitable environment for the formation and development of the embryo; while that of the sire includes the cock's ability to mate successfully and the quantity and quality of semen deposited (Brillard, 2003).

In all avian species, as well as in other animals in the animal kingdom, increase in age has an adverse effect on reproductive success. These factors which may be from both sexes also seems to be subject to increase in the age of the bird (Hocking and Bernard, 2000; Gumułka and Kapkowska, 2005).The precise factors that influence or cause the age related decline in reproduction are poorly understood (Bramwell, 2009). It has been generally considered that this reduction in fertility was caused by a decline in mating activity that was largely attributable to the heavy weight and poor physical condition of older males (Hocking, 1990).

El-Fiky (1994) reported that fertility rates in Japanese quail ranged between 75.7 and 81.0%. Lower estimates of 67.0 and 72.9% for the fertility percentages of Japanese quail were reported by Aboul-Hassan *et al.* (1999) after 3 generations of selection for increased 6 weeks body weight. High estimates of 81.7, 83.4, 84.0 and 93.9% were reported for this trait by El–Fiky (2002). Higher estimates of 93.8% and 94.29% were reported by Atia (1998) and El-Shafei (1993) respectively. A wide range (66.7-85.8%) for the fertility percentage in Japanese quail was reported by Sachdev *et al*. (1985). It seems generally, that this bird is highly fertile, a matter which should be utilized efficiently in meat and egg production enterprises.

2.9 Mating Ratio

There are two ways in which the action of the breeder can change the genetic properties of the population, the first is by the choice of individuals to be used as parents, which constitutes selection, and the second by controlling the way in which the parents are mated, which embraces inbreeding and crossbreeding beside random mating which protect the genetic constitution of population as fixed from one generation to another (Falconer, 1960).

Many investigators studied the effect of different sex ratios on growth and reproductive traits of Japanese quail. Studying this non-genetic factor, Mandour and Sharaf (1993) found that no significant differences in fertility occurs between different mating ratio from 1:1 to 1:4 in Japanese quail aged from 8 to 32 weeks; which resulted in fertility values of 66.20, 64.60, 63.04 and 62.25%, respectively. Narahari *et al*. (1988) studied different sex ratios of 1:1 to 1:6 and found that sex ratios 1:1 and 1:2 gave higher fertility percentages compared to the other sex ratios studied. It was observed that the peak of fertility percentage was obtained from 1:2 sex ratio (95.0%) and declined to (86.4%) with 1:6 sex ratio. This agrees with the findings of Gebriel (2002) who studied the influence of mating ratio on reproductive performance in Japanese quail. He found that the mating ratio 1:1 to 1:6 male to female(s) ratio resulted in fertility values of 85.15, 92.93, 94.55, 90.76, 88.66 and 82.97% respectively. Narahari *et al*. (1988) reported that peak of fertility was obtained from 1:3 ratio at 95.4% and declined significantly to 86.4 with 1:6 male to females ratio in quails aged 10 to 18 weeks. Mating ratio was shown to have an influence on hatchability (Mandour and Sharaf 1993). They both observed that mating ratios of 1:1, 1:2, 1:3 and 1:4 male to females at 8 weeks of age through 32 weeks of age had percent of hatchability of 72.15, 72.03, 63.65 and 59.04% respectively. This agreed with Narahari *et al*. (1988) who observed that sex ratios 1:1 and 1:2 gave higher hatchability percentages than with other mating ratios. Optimum mating ratio of Japanese quail males to females are considerably lower than optimum ratio reported for other species of poultry (Mandour and Sharaf 1993).

2.10 Blood Parameters in Japanese Quail

Over the years many researchers have focused their genetic studies on improving only economic traits. This improvement of physiological parameters is negatively associated with some aspects of immunological performance in poultry and has led to undesirable effects as reported by Yunis *et al.* (2000) and Cheema *et al.* (2003). A broader perspective of improved and efficient genetic study has emerged because, selection, breeding and genetic improvement have a marked effect on characteristics of the blood biochemistry; as researchers utilize the biochemical parameters of the blood as markers in livestock species to enhance productivity and reproductive performance (Nguyen and Tran, 2003 and Emmerson, 2003). Pagot (1992) noted that genetic resources such as serum enzymes, serum proteins and bilirubin have been established as genetic markers in farm animals.

A wide range of the blood biochemistry and its relationship to poultry species performance has been reported in literature. In chickens, Abdel Latif (2001) looked at total protein in *Dandarawi* and *Golden Montazah* hens; glucose was studied in *Dandarawi* and *Golden Montazah* chickens (Attia, 2002) and local Iraqi fowl (Al-Hillali *et al*., 2007); Alkaline Phosphatase activity in Rhode Island (Orunmuyi *et al.*, 2007) and Glutathione peroxidase enzyme activity in two broiler strains (Ragab *et al.* 2010) while Dutta (2010) studied the haemato-biochemical parameters in a number of chicken breeds,. While in Japanese quail, Ragab (2001) studied albumin and globulin levels; Bahie El-Deen *et al.* (2009) studied total protein while Bahie El-Deen *et al.* (2009) and Ashraful (2013) reported values for blood calcium.

Commercial poultry breeding has amongst its objectives, the improvement of production potential and disease resistance. The blood biochemical analysis is a valuable tool for evaluating traits in breeding for high productivity (Obeidah *et al.*, 1978) and as indicator for the health of animal and helps both in diagnosis and clinical monitoring of disease (Karesh *et al.*, 1997). Its evaluation indicates the extent of damage in various vital organs and status of the disease. Serum biochemical profiling has been used in several species of domestic livestock to monitor herd health and to detect subclinical disease. Existence of any significant relationship between blood biochemical features (such as Alkaline Phosphatase and glucose) with animal performance is needed for the design of breeding programs aimed to improve the balance between production and health traits.

2.10.1 Glucose

The important position of glucose in metabolism has led many workers to suggest that levels of blood sugar may be a factor controlling food-seeking behaviours (Richardson, 1970). In Japanese quail, some studies found positive correlation between plasma glucose with body weight at hatch (Peebles *et al*., 2005), at 4 and 8 wks of age (Hassan, 1993) and at 8 wks of age (Alm El Dein *et al*., 2008), while, Attia, (2002) found negative correlation between plasma glucose and body weight at 8 wks of age. Several investigations were conducted to relate chickens performance with the blood glucose level. Kalamah (1995) observed the relationship of glucose with sexual maturity and egg production in chickens, Attia (2002) related plasma glucose with growth traits in Dandarawi ans Golden Montazah chickens, while Alm El Dein *et al*. (2008) related blood glucose with prediction of laying hens performance.

The level of blood glucose concentration has been reported for several avian species. A concentration of 380.4 mg/dl and 281.7 mg/dl was reported in female and male Japanese quail respectively (Poyraz, 1988). A lower concentration of 89.02 mg/dl was observed in Dandarawi hens at 8 wk of age (Moawad, 2002). This same value was reported for the Fayoumi hens at its peak of egg production (Abd El-Magid, 2006).

2.10.2 Alkaline Phosphatase

Alkaline Phosphatase is a hydrolytic enzyme responsible for the breakdown of phosphate esters. It is found in many body fluids and at high levels in osteoblast, canaliculi, intestinal mucosa, renal proximal convoluted tubes and placenta (Michael, 1968) but low or non existing in muscles, matured connective tissues, unossified cartilage and erythrocytes (Moss, 1974). The Alkaline Phosphatase is thought to play a role in bone formation, absorption and synthesis of fat, absorption and synthesis of protein and carbohydrate (Das and Deb 2008)

Alkaline Phosphatase activity has been studied in various avian species. No difference was observed in its activity in different sex of Japanese quail (Itoh *et al*, 1998) and at different age in crossbred ducks (Krasnodebska *et al*, 1997). However, Orunmuyi (2006) reported difference in its activity at different age in two strains of Rhode Island chicken. Also Pal *et al*. (1996) reported that activity of Alkaline Phosphatase differed among 4 varieties of guinea fowl and between slow and fast feathering birds.

2.11 Genetic Parameters

Knowledge of genetic parameters is useful in designing efficient breeding system. Estimation of genetic parameters is primordial to the establishment of strategies to be used in animal breeding programs. This is because with the study of these parameters, the evaluation of response to selection for a trait and genetic associations among traits become possible. Consequently, Pirchner (1983) stated that the accurate estimates of genetic parameters are essential for construction of applied breeding programs. Falconer (1960) reported that genetic parameters generally include heritability and repeatability of the traits under consideration as well as the genetic and phenotypic correlations among them. These hereditary factors describe genetic and environmental variation and might vary among populations and environments and should thus be estimated in different populations and environments. Although, several methods for genetic parameters estimation can be applied as realized heritability or parent-offspring regression, the most frequently used method is the variance component estimation with REML estimator (Firat, 1996; Saatci *et al.*, 2003). Estimation of genetic parameters is primordial to the establishment of strategies to be used in animal breeding programs because with the study of these parameters, the evaluation of response to breeding for a trait and genetic associations among traits become possible. Several estimations of genetic parameters of traits in Japanese quail have been reported (Abdel-Mounsef, 2005; Vali *et al*., 2005; Abdel-Tawab, 2006; Dionello *et al*., 2006; Mielenz *et al*., 2006; Saatci *et al*., 2006; Shokoohmand *et al*., 2007).

2.11.1 Heritability

The heritability expresses the proportion of the total variance that is attributable to the average effects of genes, which determines the degree of resemblance between relatives. This degree of resemblance between individuals is measured by heritability (Falconer, 1989). Lush (1949) defined heritability in the broad sense as the proportion of the genotypic variance to the phenotypic variance which includes all kinds of variances in gene action, i.e. additive, dominance and epistatic, while the proportion of the additive genetic variance to the phenotypic variance is heritability in the narrow sense.

i.e H^2 = heritability in the broad sense.

$$\frac{V_G}{V_P}$$

h^2 = heritability in the narrow sense.

$$\frac{V_A}{V_P}$$

but $V_P = V_G + V_E$

so $V_P = V_A + V_D + V_I + V_E$

where

V_G is genetic or heritable variance,

V_P is observed variance or phenotypic variance

V_E is variance due to environment

V_A is additive genetic variance

V_D is variance due to due to dominance

V_I is epistatic variance

Pirchner (1983) reviewed various techniques used to estimate the heritability of different quantitative traits and then summarized them as follow:

1-Paternal half–sib correlation ($4\ \sigma^2_S / \sigma^2_P$).

2-Maternal half-sib correlation ($4\ \sigma^2_D / \sigma^2_P$).

3- Full –sib correlation ($2(\sigma^2_S + \sigma^2D) / \sigma^2_P$).

4- Parental–offspring regression (σ_{OP} / σ^2_P).

5- Realized heritability (R/S).

Where: σ^2S is the estimated sire components of variance,

σ^2_D is the estimated dam components of variance

σ^2_P is the phenotypic variance,

σ_{OP} is the parent-offspring covariance,

R is the response to selection

and S is the selection differential.

The success of the breeder or experimenter in observing or changing the characteristics of the population can be predicted with the knowledge of heritability. It is worthy to note that several factors could be the reason for a variation in estimates for certain trait which show a wide range of variation; these variations may reflect a real discrepancy between populations, the conditions under which they are studied (climate, nutrition and management), the mode of estimation, strain or breed, sampling error due to small data set or sample size and measurement errors which can also result in fluctuations of estimates. A change in any of these conditions influences heritability estimates (Prado-Gonzalez *et al.*, 2003). Therefore, discrepancies between heritability estimates for a particular trait should be considered the normal rather than the exception. Heritability estimates differ according to the character. Abdel-Mounsef (2005) reported that characters with the lowest value for heritability are those most closely connected with reproductive fitness, while the characters with the highest heritability are those that might be judged on biological grounds which are determinants of natural fitness. Furthermore, when the heritability of a certain character is high, emphasis should be made on mass selection but when low, it should be made upon pedigree, sib and progeny tests.

A wide range of heritability estimates for body weight in Japanese quail has been cited by many researchers which normally made use of body weight at different ages and often different methods to estimate the heritability. (Bahie El–Deen, 1999; Abdel-Fattah, 2001; El–Fiky, 2005; Abdel-Mounsef, 2005; Vali *et al.,* 2005 and Abdel-Tawab, 2006). Consequently, Minvielle (1998) reviewed reports from several studies and stated that heritability estimates for body weights of Japanese quail at 4 and 8 weeks of age ranged from 0.47 to 0.74. Lower estimates for body weight at 35 days of age and body weight at 42 days of age were estimated as 0.30 and 0.25, respectively by Vali *et al.* (2005).

The realized heritability estimates for BW 2, 4, 6 cited by several investigators averaged 0.25, 0.38 and 0.21, respectively (Nestor *et al.,* 1982, Darden and Marks, 1988a, Caron *et al.,* 1990, Hassan, 1994, Helal, 1994, Marks, 1996 and Noda *et al.,* 2003). Higher realized heritability for males than females (0.49 vs 0.36) at the 4th generation of selection for high 5-week body weight was obtained by Metodiev and

Drbohlav (1998). Also, moderate realized heritability for small BW_6 was reported by Piao *et al.* (2004).

For Body weight gain, Abdel-Fattah (2006) reported that heritability estimates during different periods of growth ranged from 0.01 to 0.71 in males, 0.03 to 0.52 in females and 0.02 to 0.37 in the combined sexes, regardless of the estimation method. Growth rates for male's progeny during all studied periods of growth had similar trend of body weight having higher heritability than the females due to non-additive effects. However, females had higher heritability based on sire component of variance during the periods 1-21 and 1-42 higher than those based on dam component of variance indicating sex-linked effects.

2.11.2 Phenotypic correlation

The phenotypic correlation between any two quantitative traits describes the extent to which individuals above average for one trait tend to be above, below or near the average for the other trait (Pirchner, 1983). It measures the linear association between traits; it predicts the deviation from the population mean in one trait of an individual as a function of its deviation from the population mean of other when both traits are measured in their respective phenotypic standard deviation units. Hazel (1943) reported that the knowledge of correlations among productive traits is essential for the construction of selection indices designed to maximize the rate of genetic improvement.

2.11.3 Genetic correlation

The phenotypic correlation between any two traits is not a reliable estimate of the genetic relationship existing between them. Genetic correlations are important to animal breeders because they represent the correlation between the breeding values of the two traits. The genetic correlation may have a different sign and frequently has widely different magnitudes from the corresponding phenotypic correlation. The true cause of genetic correlation among traits is mainly gene pleiotropy, i.e. genes may affect two traits at the same time, so that both tend to be inherited in association with each other (permanent cause of genetic correlation). Genetic correlation between traits will result in a correlated response to selection (Falconer, 1989). This effect may not necessarily be in the same direction for both traits. Linkage, i.e. genes affecting two traits being located on the same chromosome, is also a temporary cause of genetic correlation between traits. It is usually a minor cause, however, because the degree of genetic association of this sort depends on the degree of linkage of the genes affecting these traits and the state of equilibrium of the population studied. In a random mating population such resultant genetic correlation will be eroded in proportion to the amount of crossing over.

Table 2.1 Reported phenotypic and genetic correlation coefficients between pairs of different traits studied in quail as reported by some authors.

Pair of traits: Among body weights at different ages.

Authors	Year	Age	Phenotypic	Genotypic
Soften and Siegel	1974	0.2 WK	0.23	0.50
		0.4 WK	0.24	0.40
		0.6 WK	0.25	0.48
		2.4 WK	0.78	0.88
		2.6 WK	0.47	0.67
		4.6 WK	0.67	0.81
Marks	1975	0.2 WK	0.15-0.41	
		0.4 WK	0.02-0.31	
		2.4 WK	0.69-0.87	
Narayan	1976	0.2 WK	0.34	
		0.5 WK	0.15	
Narayan	1977	0.2 WK	0.27	0.53
		0.5 WK	0.21	0.44
		2.5 WK	0.60	0.94
Marks	1984	2.4 WK	0.91-0.98	
Kadry *et al*.	1986	6.12 WK	0.66	0.75
Darden and Marks	1988b	2.4 WK	0.76-0.83	
El-Fiky	1991	0.3 WK	0.41	0.78
		0.6 WK	0.35	0.73
		3.6 WK	0.58	1.01
Sharaf	1992	0.2 WK	0.20	0.11
		0.4 WK	0.16	0.23
		0.6 WK	0.12	0.37
		2.4 WK	0.20	0.24
		2.6 WK	0.24	0.27
		4.6 WK	0.25	0.69
Mousa	1993	1.3 WK	0.73	0.87
		1.6 WK	0.87	1.04
		3.6 WK	0.69	0.99
Bahie El-Deen	1994	0.2 WK	0.27	0.35
		0.4 WK	0.10	0.31
		0.6 WK	0.15	0.29
		2.4 WK	0.60	0.91
		2.6 WK	0.59	0.88
		4.6 WK	0.70	0.87
Abdel-Mounsef	2005	0.2 WK	0.22	0.46
		0.4 WK	0.14	0.34
		0.6 WK	0.32	0.61

Pair of traits: Among body weight and body weight gain.

Authors	Year	Age	Phenotypic	Genotypic
Narayan	1976	ADG_{2-5}, 0 WK	0.07	0.08
		ADG_{2-5}, 2 WK	0.03	1.27
		ADG_{2-5}, 5 WK	0.81	1.08
Mousa	1993	BW_1,ADG_{1-2}	0.46	0.73
		BW_1,ADG_{3-4}	0.08	2.35
		BW_1,ADG_{5-6}	0.07	-0.34
		BW_3,ADG_{1-2}	0.78	0.98
		BW_3,ADG_{3-4}	0.14	1.69
		BW_3,ADG_{5-6}	-0.14	-1.49
		BW_6,ADG_{1-2}	0.48	0.98
		BW_6,ADG_{3-4}	0.55	0.85
		BW_6,ADG_{5-6}	0.36	-1.09
El-Fiky and Aboul-Hassan	1994	7.13 WK	0.73	0.68
		7.16 WK	0.68	0.57
		13.6 WK	0.98	0.78
Shalan	1998	0.2 WK	.18-.36	-.23-0.77
		0.4 WK	-.09-.24	-.31-0.62
		0.6 WK	-.07-.23	0.05-0.46
		2.4 WK	.6-.79	0.51-1.00
		2.6 WK	.23-.87	.33-.66
		4.6 WK	.22-.54	.33-.92
Tawafeuk	2001	1.2 WK	0.55	0.79
		1.4 WK	0.47	0.78
		1.6 WK	0.43	0.67
		2.4 WK	0.80	0.95
		2.6 WK	0.74	0.93
		4.6 WK	0.83	0.96
Abouul– Hassan *et al.*	1999	BW_6, ADG_{0-2}	0.53	0.27
		BW_6, ADG_{2-4}	0.44	0.19
		BW_6, ADG_{4-6}	0.68	0.32
		ADG_{0-2}, ADG_{2-4}	0.34	0.22
		ADG_{0-2}, ADG_{4-6}	0.42	0.11
		ADG_{2-4}, ADG_{4-6}	0.33	0.23
Abdel-Mounsef	2005	ADG_{0-2}, ADG_{2-4}	0.08	0.11
		ADG_{0-2}, ADG_{4-6}	0.05	0.18
		ADG_{2-4}, ADG_{4-6}	0.10	0.21

Authors	Year	Age	Phenotypic	Genotypic
Pair of traits: Among body weight and egg production.				
Abdel-Mounsef	2005	BW_0, ASM	-0.33	0.04
		BW_0, TEN_{10}	-0.29	0.08
		BW_0, TEW_{10}	-0.36	0.07
		BW_0, DEM	-0.11	0.10
		BW_0, FR%	-0.26	0.06
		BW_0, HA%	-0.21	0.06
Pair of traits: Among body weight and carcass traits.				
Kawahara and Satio	1976	Body wt., bone wt.	-	0.17-0.40
		Body wt., heart wt.	-	0.08-0.69
		Body wt., liver wt.	-	0.46-0.65
		Body wt., gizzard wt.	-	0.17-0.40
		Body wt., muscle wt.	-	0.90-0.99
Abdel-Mounsef	2005	BW_6, Meat%	0.10	0.22
		BW_6, Bone%	0.16	0.10
		BW_6, Giblets%	0.11	0.14
		BW_6, Dressing%	0.08	0.24
Pair of traits: Among egg number and egg weight.				
Wilhelmson	1979	-	0.03-0.17	-0.01-0,08
Sharaf	1992	-	-0.33	-
Bahie El-Deen	1991	-	-0.03-.001	-0.08-0.16
Bahie El-Deen	1994	11-13 WK	0.03-0.25	-0.24-0.15
Pairs of traits:	Among ASM and egg production and carcass traits			
Mousa	1993	Geblet wt., BW_1	-0.18	-0.28
		Geblet wt., BW_3	-0.24	-0.57
		Geblet wt., BW_6	-0.37	-0.14
		Geblet wt., ADG_{1-2}	-0.12	-0.69
		Geblet wt., ADG_{3-4}	-0.41	-1.98
		Geblet wt., ADG_{5-6}	-0.01	1.24
		Bone wt., BW_1	-0.31	0.96
		Bone wt., BW_3	0.38	-0.78
		Bone wt., BW_6	-0.52	0.80
		Bone wt., ADG_{1-2}	-0.22	-0.42
		Bone wt., ADG_{3-4}	-0.62	-1.89
		Bone wt. , ADG_{5-6}	-0.18	0.87

Authors	Year	Age	Phenotypic	Genotypic
Pair of traits: Among ASM and egg production & carcass traits				
Aboul-Hassan and El-Fiky	1995	ASM, TEN_{10}	-0.28	-0.29
Abdel-Mounsef	2005	ASM, TEN_{10}	-0.11	0.15
		ASM, TEW_{10}	0.14	0.18
		ASM, DEM	0.16	0.10
		FR%, HA%	0.18	0.12
		Meat%, Bone%	0.12	0.18
		Meat%, Giblets%	0.04	0.20
		Meat%, Dressing%	0.04	0.19
Pair of traits: Among daily egg mass and body weight&body weight gain&egg production.				
Aboul-Hassan *et al.*	1999	DEM, BW_6	-0.11	0.28
		DEM, ADG_{0-2}	-0.02	0.16
		DEM, ADG_{2-4}	0.04	0.11
		DEM, ADG_{4-6}	-0.14	0.07
		DEM, ASM	0.33	0.18
		DEM, TEN_{10}	0.09	0.04
		DEM,TEW_{10}	0.23	0.18
		DEM, FR%	0.28	0.24
		DEM, HA %	0.19	0.18
El-Fiky *et al.*	1994	BW_0, ASM	0.35	1.03
		BW_3, ASM	0.46	0.88
		BW_0, FR%	-0.03	0.16
		BW_3, FR%	-0.04	0.48
		BW_0, HA%	-0.01	0.23
		BW_3, HA%	-0.04	0.14
Pair of traits: Among egg production traits.				
Aboul-Hassan	2001 b	TEN_{10}, TEW_{10}	0.58	0.58
		TEN_{10}, DEM	0.19	0.10
		TEN_{10}, ASM	-0.52	-0.48
Pair of traits: Among egg production and carcass traits.				
Abdel-Mounsef	2005	TEN_{10}, Meat%	0.07	0.08
		TEN_{10}, Bone%	0.09	0.04
		TEN_{10}, Giblets%	0.16	0.08
		TEN_{10}, Dressing%	0.12	0.14

2.11.4 Repeatability

The breeding value of an individual for breeding prediction is very important as it enables the breeder to determine the transmitting ability of each individual's desired economic trait. Repeatability measures the degree of association between records in the same animal for traits expressed more than once in an animal's life. It is also measured on the same traits taken in parents and offspring. The magnitude of the repeatability coefficient gives an indication of the number of records required to characterize the inherent transmitting ability of an individual. Its estimate shows the gain in accuracy expected for multiple measurements (Falconer, 1989). Traits such as birth weight and slaughter weight can only be measured once during the lifetime of an animal, whereas other traits like body weight, egg weight and egg number can be measure at several periods (Szwaczkowski, 2003).

Despite the scanty information about the repeatability of egg traits in Japanese quail, few values for this estimate have been obtained by some authors. Akpa *et al.* (2008) obtained repeatability estimates for egg traits which ranged from 0.58 to 0.99. This agrees with Sooncharenying and Edwards (1989) who reported that in quails all traits for egg had high repeatability estimate with coefficient of 0.80 for egg weight, 0.85 for shell thickness and 0.98 for shell weight. Also, Ayorinde and Sado (1988) observed that repeatability of egg weight ranging from 0.57 to 0.78 had been reported by other researchers for birds of different ages and genetic background. A lower value was obtained by Bennerwitz *et al.* (2007) who reported repeatability estimates in egg traits of quails to be 0.45 to 0.58. A general lower estimates was reported for fertility and hatchability and other traits related to them such as egg number, egg weight, shell thickness, and semen quality (Ansah *et al.*, 1985; Szwaczkowski, 2003).Generally the repeatability for growth traits is higher than for reproductive traits, thus it can be generally said that fewer records per individual are required for growth traits while those for reproductive traits will require larger record.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Location

The study was carried out at the Poultry Unit of the Department of Animal Science Research Farm, Faculty of Agriculture, Ahmadu Bello University, Zaria. The area is geographically located in the Northern Guinea Savannah of Nigeria at latitude 11^0 09' 06'' and longitude 7^0 38' 35'' (Ovimaps, 2012), with an annual rainfall of about 1100mm. Rainfall starts late April or early May, reaches peak in August and lasts until September. The dry season has two phases; the first is the harmattan that begins around the middle of October, with dry cold weather that ends in February. This is followed by relatively hot, dry weather from March to sometime in April, when the rains begin. The hot season temperature ranges between 21°C and 36°C while that of the harmattan ranges between 14°C to 30°C. The relative humidity varies between 19% and 35% in dry season and between 63% and 80% in the wet season. This description is as reported by Akpa *et al.* (2002).

3.2 Source of Experimental Birds

Fertile eggs from a random bred population were obtained from a private farm at Mando Road, Kaduna State and were incubated to obtain the base population of 220 Day-old chicks.

3.3 Management Practices

3.3.1 Brooding and rearing

Before arrival of the birds, heat source (lanterns, kerosene stoves, electric bulb) were put in place. These birds were brooded with electric bulb and kerosene stoves in cartons which were about 60 by 90 cm in length. The base of the cartoons was overlaid with news-papers and then wood-shavings. The birds were brooded for about 2-3 weeks and thereafter they were transferred to cages. At about 6 weeks of age the dam were individually housed in cages so as to monitor egg production.

3.3.2 Nutrition

Feed and water were provided *ad-libitum*. The experimental diet contained 26% Crude protein and 2741 K cal-ME/Kg for chick mash used from hatch until 5 weeks of age and 23% Crude protein with 2990 K cal-ME/Kg of layers mash used from 5 weeks of age (Dafwang, 2006). These diets were provided to birds in the base and first generation. The minerals and vitamins were adequately supplied to cover the requirements according to **NRC** (1994) throughout the experimental duration. Furthermore, daily routine management practices and clean environment was maintained.

3.3.3 Mating procedure

Individuals from the base population were selected at random as parents for the first generation. At the 12^{th} week of age, a mating procedure was done using a ratio of 1 male to 3 females to form a family which were housed in a pen to obtain fertile eggs for the next generation.

3.3.4 Egg collection and hatching

Hatchable eggs were collected from the twelfth week to the twentieth week of age from the base population and were marked according to sire number; batch hatching was used to ensure adequate number of chicks per sire.

Eggs were daily collected in the morning and evening, those meant for hatching were marked based on sire number and were stored in egg trays under room temperatures for a maximum of 7 days before being placed in the incubator. Eggs were incubated for 18 days in the incubator. They were maintained at a temperature of 37.8°C and a humidity of between 78-80% for 15days in the setter and were then transferred for the last 3 days of incubation into the hatcher (90% humidity) which was divided into marked compartments according to sire number. Hatched chicks were colour marked according to sire number; this marking was repeated at two weeks of age until the birds were wing tagged at four weeks.

3.4 Blood Collection and Laboratory Analysis

About 1 ml of blood was collected from the wing vein of the birds at the 6th week of age. Blood glucose levels was immediately determined, its concentration was quantitatively measured based on enzymatic colorimetric method according to Trinder (1969) using glucometer, then the blood was allowed to stand for 24hrs after which a pipette was used to transfer the plasma into sample bottles containing no anticoagulant which were then frozen until further biochemical analysis.

The Alkaline Phosphatase levels were determined according to Kind and King (1954). This is an enzymatic process which involves the release of phenol from phenyl phosphate by enzymatic hydrolysis. This process occurs at a pH of 10 in which the phenol released reacts with 4-aminophenazone which is an oxidising agent producing a red colour proportional to the degree of enzymatic reaction.

Table 3.1 Experimental Chick and Breeder Diet (Kg)

Ingredient	Starter	Breeder
Maize	45	47
Maize offal	2	
BDG	2	
Blood meal	3	3
GNC 44%	37.61	35
Soya cake	2	
Fullfat soya		3.12
Fish meal (local)	3	2
Limestone	0.5	5.2
Bone meal	3	2
Palmoil	1	1.67
Salt	0.3	0.3
Vit TM premix	0.27	0.27
L-Lysine	0.2	0.19
Dl-Methionine	0.12	0.25
Total	100	100
Calculated Analysis		
CP (%)	26.00	23.00
ME: (Kcal/kg)	2764	2900
Ca%	1.22	2.59
Avail P%	0.62	0.45
Ca : P ratio	2.0	5.8
Lysine %	1.32	1.21
Met + cys (%)	0.88	0.92

3.5 Recording of Data

Records for eggs in the hatchery includes: the batch number, number set, number hatched, number dead in shell and the number of clear eggs. Records of body weight at 4 and 8 weeks of age were also taken. For the hens the age at sexual maturity, weight at sexual maturity and weight of individual egg up to 11 weeks of age were recorded in the record book. The instrument used to record the body weights and the individual daily egg weight was a pocket mini digital scale (Diamond Series A04) with a sensitivity of 0.1g.

3.6 Data Collection

The following data were estimated:

$$\text{Average growth rate} \quad \frac{W_2 - W_1}{T_2 - T_1}$$

$$\text{Relative growth rate} \quad \frac{W_2 - W_1}{\frac{1}{2}(W2 + W1)}$$

Where W2 = 8-week weight

W1 = 4-week weight

T1 = Initial time

T2 = Final time

- Age of individual hen at sexual maturity which is the day of first egg.

- Average egg weight: estimated as the cumulative individual hen egg weight divided by the number of eggs laid.

- The ratio of egg weight to 4-week body weight. Estimated as

$$\frac{\text{Average egg wt}}{\text{4-week body wt}}$$

- Alkaline Phosphatase activity: estimated using spectrophotometer

- Glucose level: estimated using glucometer.

3.7 Statistical Analysis

Means and differences in means among sexes were evaluated and separated using the least square means of SAS 9.0 (SAS, 2002). Phenotypic correlation among traits was evaluated using the correlation procedure of the SAS software while Repeatability estimates were calculated using variation component of the same software.

The model for this study is a fixed effect one-way model shown below

$$Y_{ijk} = \mu + G_i + S_{ij} + e_{ijk}$$

Where μ is the mean

G_i = effect common to the i^{th} generation

S_{ij}= effect common to all animals of the J^{th} sex within the i^{th} generation

e_{ijk}= error

Y_{ijk}= The observation of the k^{th} progeny of the j^{th} sex of all animals within the i^{th} generation

Phenotypic correlation among traits was evaluated using the correlation procedure of the same SAS software. It was expressed as:

$$rp = \frac{COVp}{\sqrt{Vpx\ Vpy}}$$

where rp is the phenotypic correlation,

x and y are the parameters studied

COVp is the appropriate covariance

and **Vp** is the standard deviation.

The repeatability R was estimated using the standard expression giving by falconer (1989), expressed as

$$R = \frac{\sigma^2_p}{\sigma^2_p + \sigma^2_e}$$

Where σ^2_p is the individual variance component

σ^2_e is the variance due to error

$(\sigma^2_p + \sigma^2 e)$ is the total phenotypic variance

CHAPTER 4

4.0 RESULTS

4.1 Growth and Blood Biochemistry in Japanese Quail

Table 4.1 shows the Least Square Means and Coefficient of Variation of some economic traits and blood biochemistry in male and female Japanese quail (Base generation). There was significant difference ($P<0.01$) in 8-weeks body weight (BW_8), Average Growth Rate (Agr), weekly Body Weight Gain (WBwt) and Relative Growth Rate (Rgr) with the females consistently being heavier than the male. However at 4-weeks body weight (BW_4) the male and female had no significant difference ($P>0.01$). For the growth parameters, the males had a lowest value for coefficient of variation of 8.85% in BW_8 and a highest value of 20.15% in BW_4, while the females had a lowest value of 12.12% and a highest value of 19.50% for BW_8 and BW_4 respectively. The blood biochemistry were statistically similar in both males and females however the males had higher blood glucose (Glu) and lower blood Alkaline Phosphatase (ALP) levels than the females.

Table 4.2 shows the Least Square Means and Coefficient of Variation of some economic traits and blood biochemistry in male and female Japanese quail (First generation). For growth traits, the highest and lowest coefficient of variation were found in the females and it was 13.49% for Rgr and 25.56% in BW_4. Except for the initial body weight (BW_4) which was statistically similar ($P>0.01$) in both sexes, the females had consistent higher significant difference ($P<0.01$) for other growth traits as

Table (4.1): Least Squares Means and Coefficient of Variation of some economic traits and blood biochemistry in male and female Japanese quail (Base generation).

	Male		Female	
Traits	LSM ± SE	CV	LSM ± SE	CV
BW_4 (g)	48.85 ±1.12	20.15	49.13±1.08	19.50
BW_8 (g)	123.91^{b}±1.68	8.85	140.59^{a}±1.60	12.12
Agr (g)	75.64^{b} ±1.59	16.65	91.43^{a} ±1.53	16.09
WBwt (g)	18.91^{b} ±0.40	16.65	22.86^{a} ±0.38	16.09
Rgr (g)	0.88^{b} ±0.02	18.73	0.97^{a} ±0.02	13.71
Glu (mg/dl)	195.80±14.97	29.91	169.66±12.01	37.46
ALP (IU)	164.94±39.98	58.21	222.17±19.51	66.74

^{ab}Means with different superscripts on the same row are significantly different (P<0.01)

BW_4 = Body weight at 4 weeks; BW_8 = Body weight at 8 weeks; Agr= Average growth rate; WBwt= Weekly body weight gain; Rgr = Relative growth rate; Glu = Blood glucose concentration; ALP = Blood Alkaline Phosphatase activity.

Table (4.2): Least Squares Means and Coefficient of Variation of some economic traits and blood biochemistry in male and female Japanese quail (First generation).

	Male		Female	
Traits	LSM ± SE	CV	LSM ± SE	CV
BW_4 (g)	36.56±0.96	23.70	38.71±0.98	25.56
BW_8 (g)	96.50^{b} ±1.83	15.55	106.48^{a} ±1.86	18.47
Agr (g)	59.90^{b} ±1.37	21.04	67.95^{a} ±1.39	19.84
WBwt (g)	14.98^{b} ±0.34	21.04	16.99^{a} ±0.35	19.84
Rgr (g)	0.90^{b} ±0.02	18.47	0.94^{a} ±0.02	13.49
Glu (mg/dl)	339.14±10.23	21.72	335.97±9.33	27.81
ALP (IU)	128.92±10.12	49.80	144.55±9.63	51.88

[ab]Means with different superscripts on the same row are significantly different ($P<0.01$)

BW_4 = Body weight at 4 weeks; BW_8 = Body weight at 8 weeks; Agr= Average growth rate; WBwt= Weekly body weight gain; Rgr = Relative growth rate; Glu = Blood Glucose concentration; ALP = Blood Alkaline Phosphatase activity.

was observed in the base generation. There was no significant difference (P>0.01) in the blood biochemistry, however, the females had lower blood glucose (Glu) and higher blood Alkaline Phosphatase (ALP) levels when compared with the males.

Table 4.3 shows the Least Square Means and Coefficient of Variation of the pooled data for some economic traits and blood biochemistry for both sexes. The Coefficient of Variation was quite close between the females and males for corresponding trait. For the growth traits, the females had higher Coefficient of Variation for BW_8, Agr and WBwt, while in the males it was higher for BW_4 and Rgr. The blood glucose and ALP respectively had a Coefficient of Variation of 31.82% and 50.99% for the males and 42.03% and 64.42% in the females.

Table 4.4 shows the Least Square Means and Coefficient of Variation of pooled data for some economic traits and blood biochemistry for the two generations. For the growth traits, the base generation had significant differences (P<0.01) for $BW_{4,}$ $Bw_{8,}$ Agr, WBwt and Rgr than the first generation. In the base generation the Coefficient of Variation for growth traits had a lower array with the lowest value of 16.09% for (Rgr) and the highest value of 19.81% for (BW_4) while that in the first generation were more widely from 16.11% for (Rgr) to 24.39% for (BW_4). For the blood biochemical factors, the base generation was significantly higher for Glu but was significantly lower in estimates for ALP when compared to the first generation. The blood Coefficient of Variation had a value of 34.39% and 25.27% for glucose, 66.84% and 51.11% for ALP in the base and first generation respectively.

Table (4.3): Least Squares Means and Coefficient of Variation of pooled data for some economic traits and blood biochemistry for both sexes.

	Male		Female	
Traits	LSM ± SE	CV	LSM ± SE	CV
BW_4 (g)	42.11±0.85	25.99	43.71±0.85	25.24
BW_8 (g)	108.88^{b} ±1.73	17.52	122.83^{a}±1.72	20.44
Agr (g)	67.01^{b} ±1.30	22.11	79.22^{a} ±1.28	23.14
WBwt (g)	16.75^{b} ±0.32	22.11	19.80^{a} ±0.32	23.14
Rgr (g)	0.89^{b} ±0.01	18.59	0.95^{a} ±0.01	13.63
Glu (mg/dl)	304.82±12.20	31.82	285.90±10.66	42.03
ALP (IU)	132.32±12.84	50.99	167.99±10.86	64.42

[ab]Means with different superscripts on the same row are significantly different (P<0.01)

BW_4 = Body weight at 4 weeks; BW_8 = Body weight at 8 weeks; Agr= Average growth rate; WBwt= Weekly body weight gain; Rgr = Relative growth rate; Glu = Blood Glucose concentration; ALP = Blood Alkaline Phosphatase activity.

Table (4.4): Least Squares Means and Coefficient of Variation of pooled data for some economic traits and blood biochemistry for the two generations.

	MEANS			
	Base generation		First generation	
Traits	LSM ± SE	CV	LSM ± SE	CV
BW_4 (g)	49.00^a±0.76	19.81	37.62^b±0.71	24.39
BW_8 (g)	132.57^a ±1.40	10.86	101.41^b ±1.30	17.21
Agr (g)	83.85^a ±1.18	16.38	63.86^b ±1.10	20.42
WBwt (g)	20.96^a ±0.30	16.38	15.96^b ±0.27	20.42
Rgr (g)	0.924±0.02	16.09	0.92±0.01	16.11
Glu (mg/dl)	182.73^b±11.56	34.39	337.41^a±6.92	25.27
ALP (IU)	215.20^a±17.52	66.84	135.78^b±8.81	51.11

^{ab}Means with different superscripts on the same row are significantly different (P<0.01)

BW_4 = Body weight at 4 weeks; BW_8 = Body weight at 8 weeks; Agr= Average growth rate; WBwt= Weekly body weight gain; Rgr = Relative growth rate; Glu = Blood Glucose concentration; ALP = Blood Alkaline Phosphatase activity.

4.2 Reproductive and Blood Biochemistry in Female Japanese Quail

Table 4.5 shows the Least Square Means and Coefficient of Variation of reproductive and blood biochemistry for the 2 generations (females only). For age at sexual maturity (ASM) and for the ratio of egg weight to 4-week body weight (EgB4), first generation was significantly higher (P<0.01) than the base generation while for estimates on weight at sexual maturity (WtAsm), egg at sexual maturity (EgAsm), average egg weight (Aveg) and egg laid at the 11th week of age (Egg11), the base generation was significantly higher (P<0.01) than the first generation.

Table 4.5: Least Squares Means and Coefficient of Variation of reproductive and blood biochemistry for the 2 generations (females only).

	MEANS			
	Base generation		First generation	
Traits	LSM ± SE	CV	LSM ± SE	CV
ASM (days)	52.78^{b}±0.99	9.25	67.52^{a}±0.69	8.72
WtAsm (g)	158.26^{a} ±2.01	8.56	134.97^{b} ±1.41	7.55
EgAsm (g)	8.68^{a} ±0.16	11.91	8.02^{b} ±0,12	10.69
Aveg (g)	9.40^{a} ±0.16	7.17	8.04^{b} ±0.11	12.54
Egg11(g)	9.65^{a} ±0.17	6.73	7.96^{b} ±0.12	13.54
EgB (4g/days)	0.16^{b} ±0.01	25.06	0.20^{a} ±0.01	29.60
Glu (mg/dl)	173.85^{b}±12.01	34.78	331.98^{a}±9.33	25.52
ALP (IU)	216.31^{a}±19.51	67.93	147.14^{b}±9.63	52.89

^{ab}Means with different subscripts on the same row are significantly different (P<0.01)

ASM=Age at sexual maturity; WtAsm= Weight at sexual maturity; EgAsm= Egg at sexual maturity; Aveg= Average egg weight; Egg11 = Egg laid at the 11th week of age; EgB4= Ratio of egg weight to 4-week body weight; Glu = Blood glucose concentration; ALP = Blood Alkaline Phosphatase activity.

4.3 Correlation between Traits

Table 4.6 presents the correlation coefficients between growth traits and blood biochemistry in the base generation which has both negative and positive values. Positive and high correlations efficient were observed between BW_4 and BW_8, Agr and BW_8, and between Rgr and ALP. Those that had positive but moderate correlation coefficient were BW_4 and Glu, BW_4 and Agr, and between Rgr and ALP. The serum Glu showed negative correlation coefficient with BW_8, Agr, Rgr and ALP. The correlation coefficient between BW_4 and Agr and between BW_4 and ALP were also negative.

Table 4.7 presents the correlation coefficients for growth traits and blood biochemistry in the first generation. The values were of varying magnitude and direction but were majorly positive coefficients. Positive and high correlation coefficients were observed between BW_4 and BW_8, BW_8 and Agr and between Agr and Rgr while BW_8, Rgr both had positive correlation with other traits studied. Negative and high correlation coefficient was observed between BW_4 and Rgr. For the blood biochemistry, negative correlation coefficients were observed between Glu and BW_4, ALP and Rgr and between ALP and Glu.

Table 4.8 shows the pooled correlation coefficients for the growth traits and blood biochemistry traits. Both positive and negative relationships were observed with varying magnitude and level of significance. Positive and high correlation coefficients were observed between BW_4 and BW_8, BW_8 and ALP and between Agr and all other parameters except BW_4 and with Glu. For the blood biochemistry, ALP had a

Table 4.6: Correlation for growth and blood biochemical parameters in the base generation.

Trait	BW_4	BW_8	Agr	Rgr	Glu
BW_8	0.37^{***}				
Agr	-0.23^{**}	0.8^{***}			
Rgr	-0.81^{***}	0.24^{**}	0.73^{***}		
Glu	0.22^{ns}	-0.07^{ns}	-0.18^{ns}	-0.24^{ns}	
ALP	-0.12^{ns}	0.47^{*}	0.49^{*}	0.35^{*}	-0.04^{ns}

*** = $P<0.001$
** = $P<0.01$
* = $P<0.05$
ns = Not significant

BW_4 = Body Weight at 4 weeks; BW_8 = Body weight at 8 weeks; Agr= Average growth rate; WBwt= Weekly body weight gain; Rgr = Relative growth rate; Glu = Blood Glucose concentration; ALP = Blood Alkaline Phosphatase activity.

Table 4.7: Correlation for growth and blood biochemical parameters in the first generation.

Traits	BW_4	BW_8	Agr	Rgr	Glu
BW_8	0.69^{***}				
Agr	0.23^{***}	0.87^{***}			
Rgr	-0.62^{***}	0.11^{ns}	0.58^{***}		
Glu	-0.21^{*}	0.03^{ns}	0.20^{*}	0.29^{**}	
ALP	0.25^{*}	0.22^{*}	0.08^{ns}	-0.17^{ns}	-0.03^{ns}

*** = P<0.001
** = P<0.01
* = P<0.05
ns = Not significant

BW_4 = Body weight at 4 weeks; BW_8 = Body weight at 8 weeks; Agr= Average growth rate; WBwt= Weekly body weight gain; Rgr = Relative growth rate; Glu = Blood Glucose concentration; ALP = Blood Alkaline Phosphatase activity.

Table 4.8: Pooled correlation for growth and blood biochemical parameters in the base and first generation.

Traits	BW_4	BW_8	Agr	Rgr	Glu
BW_8	0.69^{***}				
Agr	0.29^{***}	0.88^{***}			
Rgr	-0.60^{***}	0.13^{ns}	0.55^{***}		
Glu	-0.49^{***}	-0.52^{***}	-0.39^{***}	0.16^{ns}	
ALP	0.28^{***}	0.43^{***}	0.39^{***}	-0.03^{ns}	-0.23^{ns}

*** = P<0.001
** = P<0.01
* = P<0.05
ns = Not significant

BW_4 = Body weight at 4 weeks; BW_8 = Body weight at 8 weeks; Agr= Average growth rate; WBwt= Weekly body weight gain; Rgr = Relative growth rate; Glu = Blood Glucose concentration; ALP = Blood Alkaline Phosphatase activity.

coefficient of -0.23 with Glu and -0.03 with Rgr, while Glu had a negative correlation coefficient with all traits except Rgr.

Table 4.9 shows the correlation for growth, blood biochemistry and reproductive parameters for the base generation. General trends for positive and negative correlation coefficients can be observed in this table. The first is that all the reproductive traits are positively correlated to each other. The second is that for the blood biochemical parameters ALP is moderately correlated to the reproductive traits while Glu is negatively correlated to them. Ultimately is that for the growth parameters, BW_8 is positively correlated to the reproductive parameters while BW_4 is negatively correlated to them.

Table 4.10 shows the correlation for growth, blood biochemistry and reproductive parameters in the first generation. Majority of the values showed positive correlation coefficients. Positive and high correlation coefficients were observed between BW_4 and BW_8, BW_4 and WtAsm, BW_8 and WtAsm, EgAsm and Aveg, EgAsm and Egg11, EgAsm and EgB4 and also between Egg11 and EgB4. The EgAsm showed positive correlation with all traits except ASM, while WtAsm showed positive correlation coefficients with all traits except with Glu, ASM and EgB4.

Table 4.11 shows the pooled correlation for growth, blood biochemistry and reproductive parameters. WtAsm showed positive and high coefficient correlation with BW_4, BW_8, EgAsm, Aveg and Egg11. Negative coefficient was observed between EgB4 and all the traits except Glu, ASM and EgAsm while Glu had negative correlation coefficients with all traits except ASM and EgB4.

Table 4.9: Correlation for growth, blood biochemistry and reproductive parameters for the base generation.

	BW_4	BW_8	Glu	ALP	ASM	WtAsm	EgAsm	Aveg	Egg11
BW_8	0.09^{ns}								
Glu	0.24^{ns}	-0.2^{ns}							
ALP	-0.35^{ns}	0.43^{ns}	-0.10^{ns}						
ASM	-0.50^{**}	0.13^{ns}	-0.15^{ns}	0.33^{ns}					
WtAsm	-0.05^{ns}	0.43^{*}	-0.30^{ns}	0.21^{ns}	0.24^{ns}				
EgAsm	-0.42^{*}	0.08^{ns}	-0.11^{ns}	0.12^{ns}	0.69^{***}	0.1^{ns}			
Aveg	-0.36^{*}	0.28^{ns}	-0.18^{ns}	0.01^{ns}	0.60^{***}	0.5^{**}	0.73^{***}		
Egg11	-0.26^{ns}	0.15^{ns}	-0.33^{ns}	-0.21^{ns}	0.47^{**}	0.47^{**}	0.39^{*}	0.75^{***}	
EgB4	-0.89^{***}	-0.05^{ns}	-0.19^{ns}	0.20^{ns}	0.65^{***}	0.05^{ns}	0.76^{***}	0.61^{***}	0.39^{*}

*** = P<0.001
** = P<0.01
* = P<0.05
ns = Not significant

ASM=Age at sexual maturity; WtAsm= Weight at sexual maturity; EgAsm= Egg at sexual maturity; Aveg= Average egg weight; Egg11 = Egg laid at the 11th week of age; EgB4= Ratio of egg weight to 4-week body weight;

Table 4.10: Correlation for growth, blood biochemistry and reproductive parameters for the first generation.

	BW_4	BW_8	Glu	ALP	ASM	WtAsm	EgAsm	Aveg	Egg11
BW_8	0.74^{***}								
Glu	-0.18^{ns}	0.01^{ns}		-					
ALP	0.30^{*}	0.27^{*}	0.08^{ns}						
ASM	-0.49^{***}	-0.55^{***}	-0.01^{ns}	-0.34^{*}					
WtAsm	0.46^{***}	0.57^{***}	-0.01^{ns}	0.11^{ns}	-0.20^{ns}				
EgAsm	0.02^{ns}	0.13^{ns}	0.21^{ns}	0.01^{ns}	-0.11^{ns}	0.34^{**}			
Aveg	0.02^{ns}	0.15^{ns}	0.10^{ns}	-0.18^{ns}	-0.04^{ns}	0.38^{**}	0.75^{***}		
Egg11	-0.19^{ns}	0.03^{ns}	0.29^{*}	0.01^{ns}	0.05^{ns}	0.24^{*}	0.73^{***}	0.56^{***}	
EgB4	-0.69^{***}	-0.43^{***}	0.29^{*}	-0.19^{ns}	0.25^{*}	-0.21^{ns}	0.40^{***}	0.18^{ns}	0.27^{*}

*** = $P<0.001$
** = $P<0.01$
* = $P<0.05$

ASM=Age at sexual maturity; WtAsm= Weight at sexual maturity; EgAsm= Egg at sexual maturity; Aveg= Average egg weight; Egg11 = Egg laid at the 11^{th} week of age; EgB4= Ratio of egg weight to 4-week body weight; Glu = Blood glucose concentration; ALP = Blood Alkaline Phosphatase activity.

Table 4.11: Correlation between growth, blood biochemistry and reproductive parameters for the 2 generations.

	BW_4	BW_8	Glu	ALP	ASM	WtAsm	EgAsm	Aveg	Egg11
BW_8	0.77^{***}								
Glu	-0.49^{***}	-0.58^{***}							
ALP	0.2^{ns}	0.41^{***}	-0.20^{ns}						
ASM	-0.72^{***}	-0.76^{***}	0.54***	-0.24^{ns}					
WtAsm	0.59^{***}	0.77^{***}	-0.56***	0.32**	-0.57***				
EgAsm	0.11^{ns}	0.32^{**}	-0.16^{ns}	0.12^{ns}	-0.16^{ns}	0.39***			
Aveg	0.32**	0.54^{***}	-0.38***	0.07^{ns}	-0.40***	0.64***	0.74***		
Egg11	0.28^{**}	0.52^{***}	-0.36***	0.13^{ns}	-0.44***	0.61***	0.65***	0.74***	
EgB4	-0.75^{***}	-0.48^{***}	0.37***	-0.14^{ns}	0.47***	-0.32**	0.30**	-0.00^{ns}	-0.02^{ns}

*** = $P<0.001$
** = $P<0.01$
* = $P<0.05$

ASM=Age at sexual maturity; WtAsm= Weight at sexual maturity; EgAsm= Egg at sexual maturity; Aveg= Average egg weight; Egg11 = Egg laid at the 11th week of age; EgB4= Ratio of egg weight to 4-week body weight; Glu = Blood glucose concentration; ALP = Blood Alkaline Phosphatase activity.

4.4 Repeatability of Traits in Female Japanese quail

Table 4.12 shows the repeatability estimates for reproductive parameters, growth traits and blood biochemistry in female Japanese quail. For the reproductive traits, ASM had a value of 0.77, WtAsm 0.67 and EgAsm 0.19. The growth traits had higher repeatability values with a value of 0.58, 0.67, 0.67, and 0.77 for BW_4, Agr, WkBwt and BW_8 respectively. For the blood biochemistry, ALP had a value of 0.27 while Glu a value of 0.66.

Table 4.12: Repeatability of traits in female Japanese quail

Reproductive	R	Growth	R	Blood	R
ASM	0.77	BW_4	0.58	ALP	0.27
WtAsm	0.67	BW_8	0.77	Glu	0.66
EgAsm	0.19	Agr	0.67		
Aveg	0.82	WkBwt	0.67		
Egg11	0.52				
EgB4	0.28				

R= repeatability coefficient

CHAPTER 5

5.0 DISCUSSION

5.1. Growth and Blood Biochemistry in Japanese Quail

5.1.1 Growth parameters

Body weight at different stages of growth for both sexes showed a significant difference in both the base and first generation. The same trend was observed by Abdel-Mounsef (2005); Abdel-Fattah (2006) and Abdel-Tawab (2006). Generally, the estimates of body weight of Japanese quail recorded at different ages indicate the high efficiency of this bird for growth as reported by Minvielle (2004).

The higher CV obtained for BW_4 and BW_8 at first generation (24.39 and 17.21) than base (19.81 and 10.86) was an indication that the body weight was more uniform among individuals in the base generation but more varied in the first generation.

In Table 4.3, the non significant difference observed between the values for female and male BW_4 for both the base and first generation agreed with Oguz *et al*. (1996) who obtained similar body weights for both sexes from Day-old up to 6 weeks of age. This observation failed to agree with that of other researchers who obtained conflicting results for sexual dimorphism at BW_4 showing significantly different values between female and male Japanese quail. Females were significantly ($P<0.01$) heavier than males through the period of 2 to 4 weeks of age (Abdel-Mounsef, 2005). Similarly, a higher estimate in ratio in favour of female to male body weight was observed at this age by Bahie El-Deen (2003), Abdel-Fattah (2006) and Abdel-Tawab (2006). In contrast, lower ratios of females to males BW_4 were cited by Soltan *et al.* (1987) and Aggrey *et al.* (2003) who observed that the females were significantly (P>0.01) lighter than the males through the period from 2 up to 6 weeks of age.

Values obtained from means of the pooled data in the base Generation and first Generation for BW_8 showed that the females were significantly (P<0.01) heavier than the males. The females at this age weighed 122.83 g while the males weighed 108.88 g. These values closely agrees with Wilson *et al*. (1961) who reported that males closely approached an adult size (110 g) at about 10 weeks of age, whereas females tended to grow faster and reached an adult size (135 g) at the same age. This observed weight also agrees with Mizutani (2003) who stated that adult male weighs 100 – 130 g while that of the adult female is 120 – 160 g. Abdel-Mounsef (2005); Abdel-Fattah (2006); Abdel-Tawab (2006) and Aboul-Seoud (2008) reported that estimates for body weight of males and females Japanese quail at different ages indicate that females are consistently heavier than males.

The body weight at 4-week and at 8-week were significantly higher in the base generation than in that of the first generation. Different generations having significant difference in body weight was reported by Adelaja (2012) who stated that the mean BW_4 in a random bred population of quail were 101.31 g, 123.02 g and 93.01 g in the base generation, first generation and second generation respectively. Also the value obtained for the BW_4 and BW_8 was much lower than results obtained by some researchers. This finding may point to the fact that the differences observed between the various estimates for body weight of Japanese quail recorded at different ages and generations may be possible due to one or more of the following reasons: the differences in the climatic conditions under which different flocks were reared, genetic makeup of the flock, degree of managerial activity and selection criteria used (Minvielle and Oguz, 2002; Sezer, 2007; Aboul-Seoud, 2008 and Vali, 2008).

In the base generation and first generation, the average growth rate, weekly body weight and absolute growth rate were significantly different between the females and males throughout the study. The females were consistently higher for all these traits which showed a reflection of the faster growth rate of the females when compared to the males from hatch to 8-weeks of age. The same trend was observed in body weights by Abdel-Mounsef (2005) and Abdel-Tawab (2006) who reported that sex differences in body weight were significant in favour of the females during the growing phase from 0 to 6 weeks of age. Furthermore, Marks (1978) and Aboul-Hassan (2001a) reported that females had higher growth rates than males during the different growth periods studied from hatch till 6 weeks of age.

5.1.2 Glucose and growth parameters

The 6th week value for blood glucose in the base generation is in agreement with the results obtained at the same age by Mohammed (2005) who found that sex had no significant difference on the levels of plasma glucose with values of 188.86 and 188.76 mg/dl for females and males respectively. Also, Vijay *et al*. (2010) obtained a similar value of 182.15 mg/dl at 42 days of age in a combined sexed population.

For the first generation the females and males serum glucose level of 335.97 and 339.14 mg/dl obtained disagreed with values reported by some researchers. A lower value was obtained by Sandip (2010) who obtained a blood glucose value of 296.2 and 311.4

mg/dl in female and male Japanese quail; while a higher value was obtained by El-Daly, Eman (1994) who found that at 6 weeks of age, the female and male sexes had plasma glucose levels of 414.4 and 400.5 mg/dl respectively.

Several factors have been reported to cause a wide variation in blood biochemical parameters in Japanese quail. In four close-bred flocks of quails, Jatoi *et al.* (2013) reported that in medium sized females, the serum glucose values was between 122.42 and 223.25 mg/dl, while in small sized males the values were between 121.76 and 221.05 mg/dl. Furthermore, Ali *et al.* (2012) observed that at the 5^{th}, 6^{th} and 7^{th} week the serum glucose was 559.37, 417.24 and 305.47 mg/dl respectively.

Despite the significant (P<0.01) difference between the value obtained for Glu in the base generation and first generation with values of 182.73 and 337.41 mg/dl respectively, the same trend was observed with the females having a statistical (P>0.01) similar serum glucose value to those of the males. Mohammed (2005) showed that irrespective of the interactions between season and energy level, season and sex, energy level and sex or season and energy level and sex, the 6-week of age serum glucose level showed no significant (P>0.01) difference in female and male Japanese quail. So the conditions which favour an increase in the females serum glucose levels, similarly favours the level of serum glucose in the males and vice- versa. The higher levels of blood glucose in some quail may be due to the presence of more amount of glucagon secreting alpha cells in Islets of Langerhans. This agrees with El-Ghalid (2009) who reported that such a higher level of blood glucose may be due to more of gluconeogenic hormones.

5.1.3 Alkaline-Phosphatase and growth

The wide variation coefficient of variation for Alkaline-Phosphatase in the base generation and first generation could be a useful tool in breeding and selection experiments where individuals can be selected based on this biochemical parameter and the resultant effect on the phenotype and genotype measured.

The pooled value of Alkaline Phosphatase for the females and males closely agrees with the result obtained by Tohid *et al*. (2011) who reported that at 6-week, the alkaline-phosphatase value was 231.5 I.U and 131.4 I.U in the female and male Japanese quail. A slightly higher value was obtained by Sahin *et al.* (2001) who reported an estimate of 248 I.U in a combined sex population. Much higher values were obtained by Özbey *et al.* (2004) and Sandip (2010). In a controlled and heat stressed environment, Özbey *et al,* (2004) reported Alkaline Phosphatase levels as 353.36 I.U and 338.28 I.U, while Sandip (2010) reported an estimate of 447.8 I.U and 474.6 I.U in female and male quails.

5.2. Reproductive Traits in Female Japanese Quail

Reports on reproductive traits exists in Japanese quail but it is not as common as some other poultry species probably due to some practical problems such as the small size of the bird and the need for a special battery cage or individual housing cage to measure these traits individually.

5.2.1 Age at sexual maturity (ASM)

The 52.78 days obtained as ASM in the base generation agreed with Deyab (2008) who reported 52.12 days as ASM. Similarly, for ASM, Marks (1979) reported that age at first egg through 40 successive generations ranged from 45.3 to 58.9 days. Furthermore, Aboul-Hassan and El-Fiky (1995) and Aboul-Hassan *et al*. (1999) estimated ASM in Japanese quail as 45.4 and 49.8 days, respectively. On the other hand, a lower estimate was obtained by Mizutani (2003), who reported an estimate of 38-42 days. Also, Garrett *et al*. (1972) and Wilson *et al*. (1961) reported low estimates for this trait in Japanese quail as 40 and 42 days, respectively. Similarly, in a random bred population of Japanese quail, Steigner *et al*. (1989a) reported low estimate of 42 days for the same trait.

For the first generation, a higher value of 67.52 days was obtained for ASM (Table 4.5). This value was significantly ($P<0.01$) higher than that obtained in the base generation and also cited by Aboul-Hassan *et al*. (1999), Mizutani (2003) and Deyab (2008) who gave estimates that were between 38 and 52.12days. Nevertheless, a close estimates to that obtained were reported by El-Fiky (1994); Shebl *et al*. (1996) and Tawefeuk (2001), who gave values ranging from 55.7 and 64.7 days. Furthermore, Sachdev and Ahuja (1986) found that for egg-line females with body weights at sexual maturity of 100-120, 121-140, 141-160, 161-180 and 181-200 g had an age at sexual maturity averaged 63.59, 69.97, 72.92, 77.92 and 65.56 days respectively. Soltan *et al.* (1987) reported that age at sexual maturity in a selected line for body weight at 4-week of age and control line of European quail were 71.6 and 71.8 days respectively, in group 1, and 61.77 and 65.5 days in group 2. Also in Japanese quail selected for high body weight, environmental factors such as photoperiod and nutrition resulted in either delayed sexual maturity or were not a factor when heavy weight females were compared with females from a randombred control line (Nestor et al., 1982; Steigner, *et al.*, 1992; and Anthony *et al*., 1993).

These different values for ASM cited by different researchers suggests that sexual maturity is the end result of a combination of factors including pattern of body weight gain, chronological age, environment, nutrition, photoperiod, management, and body composition of the bird. A combination of these factors must be met or satisfied for the female to become sexually matured. These observations support the conclusions of Oruwari and Brody (1988) who stated that the relationships between chronological age, body weight, body composition, and sexual maturity are complex. This emphasizes the fact that caution must be taken when trying to understand a complex process such as sexual development and care must be taken when trying to comprehend a process when measurements are taken from a single group of animals.

5.2.2 Weight at sexual maturity

The observed mean WtAsm between the base and first generation which were significantly ($P<0.01$) different from the base generation having a value of 158.26 days and the first generation 134.97 days, may be a reflection of the faster growth rate in the base generation. Body weight differences during the prebreeding period had been associated with changes in age at sexual maturity in chickens and quails (Shebl, 1991; Ghanem, 1995; Camci *et al.*, 2002 and Meky, 2007). Wide variations within individuals in the same generation was reported by Sachdev and Ahuja, (1986) who reported that for egg-line females with a body weight of 100-120, 121-140, 141-160, 161-180 and 181-200g at sexual maturity, age at sexual maturity averaged 63.59, 69.97, 72.92, 77.92 and 65.56 days respectively.

5.2.3 Egg parameters

The base generation had a higher value in the egg weight parameters which includes egg at sexual maturity (EgAsm) and average egg weight (Aveg). This could be as a result of being heavier at sexual maturity. Furthermore, the ratio of the egg weight to the initial body weight (EgB4) was higher in the base generation than the first generation. This is because the first generation was lighter at maturity and their egg weights were comparatively similar to those of the base generation.

The observed average egg weight agreed with those cited by several authors. For egg estimates, Kohler (1981) reported egg weight of 9.1 to 10.9 g in a selection experiment for improving this trait. Asasi and Jaafar (2000) reported values for egg weight that ranged between 9.76 and 11.63 g. Higher estimates for egg weight were reported by Bahie El-Deen *et al*. (1998); Ali *et al*. (2002) Abdel-Azeem (2005) and Abdel-Tawab (2006) ranging from 10.00 to 11.86 g. Furthermore, Inal *et al*. (1996) and Aboul-Seoud, (2008) gave higher values for egg weight which ranged between 10.94 and 13.23 g in divergent selection experiment for body weight at 5 weeks of age through five generations.

Environmental factors have been shown to have or not to have great effect on egg production. Faqi *et al*. (1997) reported that egg weight was reduced at the higher ambient temperature. Munir and Mohammed (2010) reported that ambient temperatures above 30 ^{o}C are considered to have detrimental effect on the performance of laying Quail hens. Prabakaran (1992) reported that egg weight was not affected by season but henday and egg production of Japanese quail at 13 to 24 weeks of age during summer was lower than in other seasons.

5.3 Correlation between Traits

5.3.1 Phenotypic correlation between growth traits

The phenotypic correlations between body weights gave values that were positive and moderate to high which agreed with that reported by Bahie El- Deen (1994); Farahat (1998); Shalan (1998) and Abdel Fattah (2006). Furthermore, Kadry *et al.* (1986) reported positive correlation between BW_6 and BW_{12} estimated as 0.66 and Magda *et al.* (2010) reported that phenotypic correlation between hatch and two week, four week and two week and also hatch and four week body weights were 0.15 to 0.41, 0.02 to 0.31 and 0.69 to 0.87 respectively in Japanese quails. This agrees with Aboul-Seoul (2008) who obtained phenotypic correlations of males between body weight at hatch and body weight at 7, 14, 21, 28, 35 and 42 days were 0.31, 0.30, 0.25, 0.19, 0.16 and 0.15 respectively. All phenotypic correlation estimates between weights at different ages were positive with the magnitude generally decreasing as the interval between weighing increased Abdel-Fattah (2006). This positive correlation between growths may indicate that factors which cause a change (increase or decrease) in body weight at a particular age will probably results in similar experience throughout its growth phase.

5.3.2 Phenotypic correlation between growth traits and body weight

The correlation for growth rates and body weights had an array from positive to negative values. Bahie El-Deen (1994) and Adeogun and Adeoye (2004) reported only positive, high and significant relationship between body weights at different ages and average gain in Japanese quail. While Abdel-Fattah (2006) reported positive and negative values. He stated that growth rate from 3 to 4-week of age was positively correlated with BW_6 being 0.14, 0.25 and 0.22 for males, females and combined sexes, respectively, whereas negatively correlated with body weight from hatch up to 7 wk of age ranging from -0.07 to -0.74. Thus the values obtained in the correlation between body weight and growth rate may depend on the method of growth estimate and the age at which such growth change is estimated in the bird.

5.3.3 Phenotypic correlation between growth traits and age at sexual maturity

The phenotypic correlation between body weight and ASM had estimates that were generally negatively and highly correlated. This finding agrees with observation of Kadry *et al*. (1986); Bahie El-Deen (1994) and Shebl *et al*. (1996), who reported negative phenotypic correlation between body weight and age at sexual maturity. Magda *et al.* (2010) reported that the phenotypic correlation between age at sexual maturity and 6-wk body weight were -0.34. Deyab (2008) stated that the estimates between body weights and reproductive traits are small and negative in magnitude. The result obtained indicates that selection or breeding for increased body weight will lead to an increase in reproductive ability of the bird.

On the other hand, El-Ibiary *et al*. (1966) reported a positive estimate of 0.22 between body weight and age at sexual maturity. Also El-Fiky, (1991) stated that the phenotypic correlation between age at sexual maturity and six week body weight was 0.73. Deyab (2008) obtained positive and moderate phenotypic correlation estimates between body weight and age at sexual maturity in a selection experiment.

From findings between body weight and sexual maturity, two inferences can be made. The first being that the correlation between age at sexual maturity and body weight which causes decrease in days to sexual maturity with increased magnitude of body weight gain implies that increasing body weight beyond a certain limit will not delay sexual maturity. Also, the value of the correlation at a particular age depends not only on the quail specie; environment and nutrition but also on the breeding method and selection criteria.

The observed weight of the bird at sexual maturity was generally positively correlated to all reproductive traits in both generations. Similar report was made by Reddish (2004) who reported that the correlations between body weight at sexual maturity with age at sexual maturity and first egg weight were positive. Generally the reproductive traits were positively correlated with one another which may indicate that factors which favour a particular reproductive trait will favour the others up till a certain level.

5.3.4 Phenotypic Correlation between Blood Glucose and Alkaline Phosphatase

The correlation between the blood biochemistry reveals that the glucose and Alkaline phosphatase were consistently negatively correlated with each other so when one was increasing in value, the other was decreasing. These blood biochemical traits being negatively correlated may indicate that factors which favour an increase in one would cause a decrease in the other. The factor causing this divergence is not totally understood, however, studies with several poultry species have clearly revealed that as birds approach laying phase the blood glucose decrease while alkaline–phosphatase has a surge. Mary and Gomathy (2008) observed that the plasma glucose level in male and female turkeys increased till maturity and then decreased gradually throughout the remaining bird’s life. Pitt *et al*. (1980) reported low plasma glucose level of 116mg/dl in Pekin duck during laying. But, plasma Alkaline Phosphatase (ALP) is a potentially useful marker for growth and secondary ossification of the osseous tissue (Viñuela and Ferrer, 1997) which greatly increases during lay for the synthesis of calcium to form the egg shell. This agrees with Bell (1960) who found that in laying hens, the Alkaline Phosphatase activity of the plasma was greatly elevated most probably because of increased osteoblastic activity and turnover showing an effort to put back bone lost in shell formation.

5.4. Repeatability of Traits in Female Japanese Quail

Despite the scanty information on the repeatability of growth, egg and blood biochemical traits in Japanese quail, the results for several of these traits are similar to those obtained by other authors. Akpa *et al.* (2008) obtained repeatability estimates for egg traits which ranged from 0.58 to 0.99. Sooncharenying and Edwards (1989) reported repeatability coefficient of 0.80 for egg weight. However lower values were obtained by Bennerwitz *et al.* (2007) who reported repeatability estimates in egg traits of quails to be 0.45 to 0.58.

The magnitude of the repeatability coefficient which gives an indication of the number of records required to characterize the inherent transmitting ability of an individual (Falconer and Mackay 1996) shows that the repeatability estimates for growth traits was high, it being greater than 58% (>0.58) which may suggest intermediate or high heritability since repeatability comprises heritability and general environmental variance. This agrees with Boake (1989) who reported that higher variation among individual compared to that within individual, i.e. high repeatability, suggests the possibility of the existence of high heritability values since repeatability sets the upper bound of heritability.

For the reproductive traits the repeatability of 0.19 (EgAsm), 0.28 (EgB4) and 0.52 (Egg11) indicates increased variation within individuals indicating additive gene action in growth traits but possible influence of environment on reproductive and blood parameters.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMEDATIONS

6.1 Summary

This study was undertaken to determine variation in growth traits, reproductive traits and biochemical parameters in Japanese quail. Correlation between growth traits, reproductive traits and biochemical parameters and repeatability of growth traits, reproductive traits and biochemical parameters were also estimated. The results for body weight at different stages of growth for both sexes showed that sex had an effect on all body weights which reveals a high efficiency of the bird for growth. Also the females had higher growth rates than the males hence were consistently heavier than the males. Furthermore the growth had an effect on the reproductive performance observed by the faster growing birds being heavier at sexual maturity, attain an earlier age at sexual maturity and having heavier eggs.

Study on the blood biochemistry revealed that generation had an effect on the level of blood glucose and Alkaline Phosphatase. Furthermore, irrespective of the generation, the females had a more extensive variation but still a similar level of blood biochemistry to that of the males for each blood biochemistry trait studied.

The correlation between body weights gave positive correlation coefficients, while that for the body weights with relative and absolute growth rates gave both negative and positive correlation coefficients. The correlation for age at sexual maturity and body weight was negative. Blood glucose and Alkaline Phosphatase was also negatively correlated to each other. The magnitude for the repeatability estimates showed that the growth had higher inherent transmission ability than blood biochemistry and reproductive traits.

6.2 **Conclusions**

It can be concluded that sexual dimorphism exists with the females having higher growth performance when compared to the males. Furthermore faster growing females had better reproductive abilities than the slower growing ones.

Body weight was negatively correlated to age at sexual maturity indicating that selection for increased body weight will reduce the days to sexual maturity in these birds. Increase in serum glucose consequently resulted to a decrease in Alkaline phosphatase and vice versa.

A higher inherent transmission ability (repeatability) of traits was observed in growth than reproductive and blood biochemistry traits indicating additive gene action in growth traits but possible influence of environment on reproductive and blood parameters.

6.3 **Recommendations**

In view of the relationship between serum glucose and serum Alkaline phosphatase further research should be done with a larger data size so as to clearly establish these blood biochemical factors as markers for productive and reproductive traits in Japanese quail.

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