GENETIC PARAMETERS OF BODYWEIGHT AND SOME ECONOMIC IMPORTANT TRAITS IN THE JAPANESE QUAIL (*Coturnix coturnix japonica*)

BY

Joshua KAYE
B.Agric.Tech. (ATBU) 2000, M.Sc. (ABU) 2005
(Ph.D/Agric./10308/2007-2008)

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA

IN PARTIAL FULFILMENT OF THE REQUIRMENTS FOR THE AWARD OF A DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
AHMADUBELLOUNIVERSITY,ZARIA
NIGERIA.

JUNE, 2014

COPYRIGHT STATEMENT

This Dissertation or any part thereof must not be reproduced in any form without the written permission of the Postgraduate School, Ahmadu Bello University, Zaria or the author.

DECLARATION

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

_____ _____

JOSHUA KAYE
B.Agric.Tech. (ATBU) 2000, M.Sc. (ABU) 2005
(Ph.D/Agric./10308/2007-2008)

CERTIFICATION

This Dissertation titled "Genetic Parameters of Body Weight and Some Economic Important Traits in Japanese Quail" by Joshua Kaye, meets the regulations governing the degree of **DOCTOR OF PHILOSOPHY in ANIMAL SCIENCE** Ahmadu Bello University, Zaria-Nigeria and is approve for its contributions to scientific knowledge and literary presentation.

_____ _____

PROF. G. N. AKPA **Date**
Chairman, Supervisory Committee
Department of Animal Science.
Ahmadu Bello University, Zaria.

_____ _____

PROF. I. A. ADEYINKA **Date**
Member, Supervisory Committee
National Animal Production Research Institute,
Ahmadu Bello University, Zaria.

_____ _____

PROF. B. I. NWAGU **Date**
Member, Supervisory Committee
National Animal Production Research Institute,
Ahmadu Bello University, Zaria.

_____ _____

DR. S. DURU **Date**
Head of Department of Animal Science,

_____ _____

PROF. A. A. JOSHUA **Date**
Dean, Postgraduate School,
Ahmadu Bello University, Zaria.

DEDICATION

This dissertation is dedicated to my wife, Mrs. Mary Joshua Kaye, Nenrit Joshua Kaye and Seyilnen Joshua Kaye.

ACKNOWLEDGEMENT

I am extremely thankful to Almighty God who through Jesus Christ bestowed on me the ability to run this programme to conclusion.

I acknowledge with deep reverence, sincerity and gratitude to my major supervisor, Prof. G.N Akpa, Dean, Faculty of Agriculture, for supervising every stage of this research work and carefully scrutinizing the initial draft of the dissertation. His personal commitment to the research work, guidance, constant encouragement, constructive criticism, support, moral advice and patience are deeply appreciated, may God reward him. I also wish to appreciate with deep sense of gratitude, my minor supervisors, Prof. I.A. Adeyinka, Head of Data Processing Unit, National Animal Production Research Institute (NAPRI), Shika and Prof. B.I. Nwagu, Programme Leader, Poultry Research Programme, National Animal Production Research Institute (NAPRI), Shika, for their kindness and cooperation to complete this Dissertation.

l extend to thanks my Lecturers in the Department of Animal Science for providing the much needed assistance and moral encouragement both during and after the research work. The HOD, Dr. S. Duru, Dr. S.B. Abdu, Departmental PG coordinator, Prof. G.S. Bawa, Dr. T.S. Olugbumi, Dr. (Mrs) M. Orumuyi, Dr. G.E. Jokthan, Dr. M. Kabir, Dr. P. Onimisi, Dr. D. Rimi, Dr. D. Zahradden, Mr. S. Yashim, Dr. H. Rabiu, Dr. A.U. Dahiru of Department of Human Anatomy, Dr. D. M. Shehu of Biological Sciences and all the Technical officers of the Department, Alhaji Isa Ramat (Sarki) the libirian I thank him for binding the thesis. I also wish to express my deep gratitude to the, other staff of the Department of Animal Science, especially those at the Farm Unit and Animal Products Laboratory for their accommodative

attitude and kind cooperation. I am also grateful to all my school mates especially Mr. Cyprian Alphonsus who put in more ideas to the final write-up , may God bless you all.

My sincere thanks go to my affectionate father, Late Nde Ayuba Kaye, who unfortunately died at the period I was writing this dissertation, my mother, Rebecca Ayuba Kaye, my wife, Mrs. Mary Kaye, Nenrit Joshua Kaye and Seyilnen Joshua Kaye, most loving brothers, sisters and in-laws for their love, good wishes, inspirations and unceasing prayers for me. I also appreciate Plateau State Government for opportunity given to me to study and also all the staff of Ministry of Agriculture especially Department of Livestock Development Services.

Friendship is the blessing miracle of God and I indeed believe that if God did not make relationship then the life we live would be dark. I am lucky to have a friend that is indeed a friend, Engr. Alexander Plang'Naan along with his cheerful wife, Gloria and daughter, Nandirmun. I say thank you for your financial assistance and prayer. God will surely reward you and your family. Mention must be made of my wife's friends, Mrs. Charity Nanzing Sallah, Mrs. Janet Aplong, Mrs. Sharon Aliu Shiknan, Mrs. Lesmond and all our neighbours. l thank you all for your concern for me and my family especially when I was away for my research work.

TABLE OF CONTENTS

Title Page ..... **i**

Copyright Statement ..... **ii**

Declaration ..... **iii**

Certification ..... **iv**

Dedication ..... **v**

Acknowledgement ..... **vi**

Table of Contents ..... **viii**

List of Tables ..... **xiii**

Abstract ..... **xv**

CHAPTER ONE

1.0 INTRODUCTION **1**

1.2 Justification of study **3**

1.3 The Specific objectives **4**

CHAPTER TWO

2.0 LITERATURE REVIEW **5**

2.1 Japanese Quial **5**

2.2 Sexual Maturity Characteristics of Female Japanese Quail **6**

2.3 Sexual Mayurity Characteristics of Male Japanese Quail **6**

2.4 Carcass Traits of Japanese Quail **7**

2.5 Bodyweight and Some Parts of Japanese Quail **8**

2.6 Egg Weight and Yolk Characteristics of Japanese Quail **9**

2.7 Egg Weight and Albumen Characteristics of Japanese Quail at Different Generations **9**

2.8 Egg Production and Weight Traits in Japanese Quail **10**

2.9 Effect of Age and Sex on Live Body Weight and Carcass Traits in Japanese Quail **10**

2.10 Slaughter Weight and Carcass Percentage Characteristics of Japanese Quail **10**

2.11 Effect of Sex and Age on Carcass Weight and Some Internal Organs in Japanese Quail **11**

2.12 Slaughter Age and Sex on Carcass and Some Inedible Traits in Japanese Quail 12
2.13 Effect of Age and Sex on Carcass and Live Body Length at Different Generations of Japanese Quail. 12
2.14 Effect of Age and Sex on Live Body Weight and Dimensions at Different Generations In Japanese Quail 13
2.15 Effect of Age and Sex on Breast Meat Acidification in Japanese Quail 14
2.16 Effect of Age and Sex on Breast Meat Colour in Japanese Quail 14
2.17 Rate of Genetic Improvement from Selection for Body Weight and Shank length 16
2.18 Genetic Improvement of Male Sexual Reproductive Traits 16
2.19 Genetic Improvement of Some Reproductive and Egg Traits in Japanese Quail. 17
2.20 Genetic Improvement in Egg Quality Traits 18
2.21 Genetic Improvement of Body Weight at Different Ages of Growth 18
2.22 Response to Genetic Improvement of Carcass Weight at Different ages of Growth in Japanese Quail 19
2.23 Heritability Based on Individual Selection for Body Weight in Japanese Quail 19
2.24 Heritability Estimates of Body Weight at Different Ages of Growth Japanese Quail 19
2.25 Heritability Estimates of Female Sexual Reproductive Traits 20
2.26 Heritability Estimates of Male Sexual Reproductive Traits 21
2.27 Heritability Estimates of Egg Quality Traits in Japanese Quail 21
2.28 Heritability for Egg Production in Japanese Quail 22
2.29 Heritability Estimates of Carcass Weight at Different Ages of Growth in Male Japanese Quail 22

CHAPTER THREE

3.0 MATERIALS AND METHODS 23
3.1 Experimental Site 23
3.2 Mating Plan 23
3.3 Management of Fertile Egg 24
3.4 Incubation and Hatching of Fertile Eggs 24
3.5 Experimental Birds and their Management 24
3.6 Data collection 25

3.6.1 Body Weight 25
3.6.2 Measurement of the Live Body Changes (g): 25
3.6.3 Sexual Maturity 26
3.6.4 Live Body Length Measurement (cm): 28
3.6.5 Carcass Trait Measurement : 29
3.6.6 Body weight gain: 30
3.6.7 Egg Production Traits: 31
3.6.8 Egg Quality Traits 31
3.6.9 Reproduction Traits: 32
3.6.10 Quail Meat Proximate Composition: 33
3.6.11 Mineral Composition of Quail Meat 34
3.6.12 Rate and the Intensity of the Muscle Acidification during Post mortem: 34
3.7 Estimation of Genetic Parameters 36
CHAPTER FOUR
4.0 RESULTS 39
4.1 Sexual Maturity Characteristics of Japanese Quails 39
4.1.1 Sexual maturity characteristics in females 39
4.1.2 Sexual Maturity Characteristics in males 39
4.2 Carcass Traits, Body length and Body Parts of Japanese Quail 42
4.2.1 Carcass traits of Japanese quail by generations and sex 42
4.2.2 BW56 Body length and some parts of Japanese quail 42
4.3 Egg Characteristics of Japanese Quail. 45
4.3.1 Egg weight, yolk and albumen characteristics of Japanese Quail. 45
4.3.2 Performance Characteristics of Quial Hens 47
4.4 Carcass Traits as Influenced by Sex, Age and Generations in Japanese Quail. 47
4.4.1 Carcass parts traits 47
4.4.2 Carcass weight and some internal organs and inedible traits 50
4.4.3 Carcass and live body dimensions 50
4.5 Breast meat quality of Japanese quail by age and sex 53
4.6 Response to Genetic Improvement in Traits of Japanese Quail 53
4.6.1 Response to Rate of genetic improvement for body weight and shank length inJapanese Quail 53

4.6.2. The rate of improvement for growth rate in body weight and shank length in Japanese quail 56
4.6.3. Estimated genetic improvement in female sexual reproductive traits of females 56
4.6.4 Estimated correlated correlated improvement in male sexual reproductive traits 59
4.6.5 Correlated improvement in some reproductive and egg traits in Japanese quail. 59
4.6.6 Response to genetic Improvement in egg quality traits 62
4.6.7 Genetic improvement of egg production at different ages in Japanese quail 62
4. 6.8 Response to genetic improvement of body weight at different ages of growth..... 62
4.6.9 Changes genetic improvement of carcass weight for different ages of growth in Japanese quail 66
4.6.10 Response to Mineral composition improvement in meat of Japanese quail 66
4.6.11 Response to chemical composition improvement for meat of Japanese quail..... 66
4.7 Realized Heritability in Traits of Japanese Quail..... 70
4.7.1 Heritability estimate based on individual selection for body weight in Japanese quail. 70
4.7.2 Heritability estimates of body weight at different ages of growth in Japanese quail 70
4.7.3 Heritability estimates of female sexual reproductive traits in female quail 70
4.7.4 Heritability estimates of male sexual reproductive traits 74
4.7.5 Heritability estimates of egg quality traits in Japanese quail 74
4.7.6 Heritability for egg production in Japanese quail. 74
4.7.7 Heritability of carcass weight at different ages of growth in male Japanese quail ... 78
4.7.8 Heritability estimates of mineral composition in meat of Japanese quail 78
4.7.9 Heritability estimates of chemical composition for meat of Japanese Quail 78
CHAPTER FIVE
5.1 Sexual Maturity Characteristics of Japanese Quail 82
5.2 Effect of sex on bodyweight..... 83
5.3 Effect of Generation of Selection and Sex on body weight and Carcass Characteristics of Japanese Quails..... 85
5.4 Breast Meat Quality of Japanese Quail 89
5.5 Realized heritability estimates for body weight 92
5.6 Heritability estimates for egg production and quality traits 94
5.7 Heritability Estimates for Carcass Weight..... 95
5.8 Heritability Estimates for male and female reproductive traits..... 95

5.9 Heritability estimates of mineral and chemical composition of Japanese quail meat 96

CHAPTER SIX

6.1 CONCLUSION 98

6.2 RECOMMENDATIONS 98

REFERENCE 99

LIST OF TABLES

Table 4.1:	Least of square means for sexual maturity of females Japanese quail by generations - - - - -	40
Table 4.2:	Least square means for sexual maturity characteristic of males Japanese quail by generations- - - -	41
Table 4.3	Least square means of carcass traits of Japanese quail by generations and sex - - - - - -	43
Table 4.4	Least square means for Bw56 BL and some parts of Japanese quail in different generations and sex - - -	44
Table 4.5	Least square means for egg weight yolk and albumen characteristics of Japanese quail at different generations and age -	46
Table 4.6	Least square means egg production and weight traits in Japanese quail by age - - - - - -	48
Table 4.7	Least square means for carcass traits in generations of Japanese quail as influenced by sex and age - - -	49
Table 4.8	Least square means for carcass weight and some internal organs and inedible traits of Japanese quail as influenced by sex, generation and age - - - -	51
Table 4.9	Least square means for carcass and live body dimensions of Japanese quail as influenced by sex, generation and age - - - - - - -	52
Table 4.10	Least square means of breast meat quality of Japanese quail by age and sex - - - - - - -	54
Table 4.11	Rate of genetic improvement for body weight and shank length of Japanese quail - - - - - -	55
Table 4.12	Response to genetic improvement for growth rate in body weight and shank length in generations of Japanese quail - -	57
Table 4.13	Response to genetic improvement in female reproductive trait at sexual maturity - - - - - -	58
Table 4.14	Response to genetic improvement in male reproductive traits at sexual maturity - - - - - -	60

Table 4.15 Correlated improvement in some reproductive and egg traits in Japanese quail - - - - - - 61

Table 4.16 Response to genetic improvement in egg quality traits - - 63

Table 4.17 Response to genetic improvement of egg production at different ages in Japanese quail - - - - - 64

Table 4.18 Response to genetic improvement of body weight at different ages of Japanese quail by sex - - - - 65

Table 4.19 Response to genetic improvement of carcass weight for different ages by sex in Japanese quail - - - - 67

Table 4.20 Response to mineral composition improvement in meat of Japanese quail by sex - - - - - - 68

Table 4.21 Response to chemical composition improvement for meat of Japanese quail by sex. - - - - - 69

Table 4.22 Realized heritability based on individual selection for body weight in Japanese quail in two generations - - - 71

Table 4.23 Heritability estimates of body weight at different ages of growth in Japanese quail - - - - - - 72

Table 4.24 Heritability estimates of female sexual - - - - 73

Table 4.25 Heritability estimates of male sexual reproductive traits in Japanese quail at sexual maturity - - - - 75

Table 4.26 Heritability estimates of egg quality traits in Japanese quail - 76

Table 4.27 Heritability estimates for egg production at different ages in Japanese quail - - - - - - - 77

Table 4.28 Calculated heritability of carcass weight at different ages in male Japanese quail - - - - - - - 79

Table 4.29 Heritability estimates of mineral composition in meat of male Japanese quail - - - - - - - 80

Table 4.30 Heritability estimates of chemical composition of male Japanese quail meat - - - - - - - 81

ABSTRACT

This experiment was conducted to study the genetic estimates for body weight and some economic important traits in Japanese quail from a foundation stock of 784 chicks, which were sexed at day 21. Selected birds of 50 sires and 150 dams based on body weight were used as parents G_0 (Unselected generations) for the next generation. Data were collected over two consecutive hatches for G_1 (selected generation one) and G_2 (selected generation two) and records collected at day 35, 42, 49 and 56 from males and females to determine the effect of selection on age and body weight at sexual maturity; the trend of growth in body weight, body length, egg quality characteristics, egg production, carcass traits in generations, sex and age of Japanese quail; the effect of sex and age on breast meat quality of Japanese quail; the rate of genetic improvement in reproductive traits, body weight, egg traits, carcass traits, mineral and chemical composition of meat in Japanese quail and the genetic parameters (h^2) based on individual selection for body weight at different ages, reproductive, egg production, minerals, chemicals, and carcass traits of Japanese quail. The results indicated that sexual maturity characteristics in female Japanese quail such as age at sexual maturity, body weight, egg weight, follicle size, oviduct weight, ovary weight, pectoral major weight and abdominal fat weight varied significantly ($P< 0.05 - 0.01$) with selection. Also in males body weight at day 35, age at sexual maturity, body weight, testicular weight, pectoral major weight and abdominal fat weight varied significantly ($P< 0.05 - 0.01$) with selection. Live body weight, body dimensions, carcass traits in males and females after selection increased between, age and sex at day 35, 42, 49 and 56 in both males and females birds. At day 56, carcass weight, % carcass weight, abdominal fat weight, % abdominal fat weight, breast weight, drumstick + thigh weight, % drumstick + thigh weight, back bone weight, % back bone weight and body length and body part lengths also improved with selection. Females

had higher part weights than males ($P< 0.05 - 0.01$). Egg quality traits increased with generations and as birds advanced in age so also did the meat quality of Japanese quail affects both the males and females water holding capacity, cooking loss, lightness, chroma colour and as birds advances in age it affects the % drip loss of the meat, cooking loss, lightness and chroma colour significantly ($P< 0.05 - 0.01$). It can be deduced from the result that there was genetic improvement in body weight, growth rate of shank length, sexual maturity in males and females traits, reproductive traits, egg traits, carcass weight, minerals and chemical composition in meat of Japanese quail. Japanese quail shows improvement in body weight, parts and dimension in both sexes, but females were heavier than males possibily because of their genetic make-up. Selection increase egg size with advances in age but decreases egg shell. The realized heritability for carcass weight, mineral composition and chemical composition ranged mostly between 0.38 to 0.08. However, the realized heritability estimates for body weight at day 35 and 42, egg quality traits, egg production traits were high, therefore, Breeders can select for those traits because of their genetic merits.

CHAPTER ONE

1.0 INTRODUCTION

Japanese quail (*Coturnix coturnix japonica*) has become a pilot animal in the field of research. This is due to its fast growth rate, early sexual maturity, high rate of egg production, short generation interval, less feed and space requirement, easy maintenance, resistance to many avian diseases and potential source of meat and egg (Ajay-Kurma *et al.,* 2000; Akpa *et al.,* 2008). However, despite the numerous advantages over other poultry birds, its breeding programme has not been fully exploited in Nigeria. In order to establish a breeding programme, it is essential to estimate genetic parameters for improving traits that are of economic value. The scale of the genetic parameters could show the amount of improvement deriavable by selection.

Some estimates of genetic parameters for various traits of domestic Japanese quail have been reported by several workers (Kawahara and Saito, 1976; Toelle *et al.,* 1991; Minvielle *et al.,* 1999; 2000; Akpa *et al*., 2006; 2008). Knowledge of the heritability of traits is essential for understanding how individual characteristics change from one generation to another in response to selection (Falconer and Mackey, 1996). Studies of heritability have mostly focused on the estimation of genetic parameters for growth, especially under different selection environments (Anthony *et al.,* 1996; Marks, 1996; Saatci *et al*., 2003). However selection rarely operates on only one trait at a time hence, if there is a genetic correlation between traits under selection, the overall response to selection will change according to the heritability of the traits examined, and strength and sign of the genetic covariance among them (Jensen *et al.,* 2003).

The Japanese quail is a sexually dimorphic bird with females having a larger body size than males, unlike other poultry species; and females require more time to reach sexual maturity than males (Reddish *et al.,* 2002). The differences in growth pattern between the sexes are also a well- known phenomenon (Balcioglu *et al*., 2005; Sezer and Tarhan, 2005). Sexual dimorphism is believed to evolve under the pressure of natural sexual selection, which implies that genes controlling sexually dimorphic characteristics differ between females and males (Mignon-Grasteau *et al.,* 2004). Therefore, it has been suggested that genetic parameters for male and female Japanese quails be estimated separately (Sefton and Siegel, 1974), otherwise, it would be assumed that genetic correlations between male and female traits are equal to one and variances of both traits are equal, which is not often the case.

Variations in live body weights of Japanese quail at 35, 42, 49 and 63 days of age showed that females had heavier body weight than males (Kawahara and Saito, 1976; Caron and Minvielle, 1990; Baumgartner, 1994; Minvielle *et al.,* 2000). Carcass weight, breast weight, breast percent and thigh weight are higher in females than males (Caron and Minvielle, 1990; Toelle *et al.,* 1991; Minvielle *et al.,* 1999; 2000). Males showed higher percentage of carcass weights than females (Caron and Minvielle, 1990; Minvielle, *et al.,* 2000). Birds slaughtered at 63 days of age had higher carcass weight compared to those slaughtered at 46 days but breast weights and breast percentage were not affected (Vali *et al.,* 2005).

Meat pH is one of the major contributing factors to poultry meat colour. Research conducted by Oguz *et al.* (2004) showed that animal model heritability estimate for pH in Japanese quail was 0.48. The authors equally indicated that the heritability of colour

characteristics in Japanese quail, namely Brightness (I), Redness (a) and Yellowness (b), estimated from animal model was 0.23, 0.45 and 0.22, respectively. Variation in pH significantly affected the storage and processing quality of poultry meat by modifying its water holding capacity and properties (Kijowski and Niewiarowicz, 1978; Daum- Thunberg and Sales *et al.*, 1997; Barbut, 1997). Low pH meat is characterized by low water-holding capacity and poor quality and is usually referred to as pale, soft and exudative (PSE) meat (Barbut, 1997; Kijowski and Niewiarowicz, 1978). High pH meat, known as dry, firm and dark (DFD), presents poor storage quality due to faster rate of off- odor production and accelerated microbial growth (Allen *et al.*, 1997).

Carcass composition of Japanese quail is known to be influenced by dietary protein (Kim and McGinnis, 1976; Annaka *et al.*, 1993; Marks, 1993; Hussein *et al.*,1996; Hashiguchi *et al.*, 1998). Lilburn and Mayer-Miller (1990) suggested that body fat and protein deposition increased and decreased, respectively by decreasing dietary protein level in broiler breeder hens. Kilkpinar and Oguz (1995) stated that feeding low protein diets increased carcass fat content and decreased carcass protein content in female quails.

1.2 Justification of study

The awareness on quail meat is beginning to gain the interest of quail producers in Nigeria, but most producers find it difficult to obtain superior quality parents to establish an outstanding breeding programme. This is a big set back to the quail industry and a challenge to Nigeria whose population is geometrically growing with low dietary protein intake. This research was therefore geared towards estimating genetic parameters for improving the carcass, meat traits and the scale of genetic parameters that will determine the amount of improvement necessary to predict response to selection.

1.3 The Specific objectives

i. The effect of selection on age and body weight at sexual maturity in Japanese quail.

ii. Effect of generations, sex and age on growth of body weight, body length, egg quality characteristics, egg production and carcass weight in Japanese quail.

iii. The effect of sex and age on breast meat quality of Japanese quail.

iv. The rate of genetic improvement in reproductive traits, body weight, egg traits, carcass traits, mineral and chemical composition of meat in Japanese quail.

v. The heritability (h^2) based on individual selection for body weight at different ages, egg production, mineral, chemical, and carcass traits of Japanese quail.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Japanese Quial

The Japanese quail is now a well-established animal model in biology and a bird used for intensive egg and meat production mainly in Asia and Europe, in the Middle East and America (Baumgartner *et al.,*1990). Studies in quails have been aimed at increasing meat and egg production. With this goal, new breeds of quails have been obtained for meat and egg type. Body weight is considered an important trait in poultry industry. Pullets of quail as meat production type for renewal of the flock or for other industries purposes should be improved to possess large body weight in order to supply a new sort of animal protein. Marks (1989), reported that selection for high 4-week body weight had positive effects on adult body weight. Egg production is of critical importance in birds not only for their reproduction but also for human consumption as the egg is a highly nutritive and balanced food. Consequently, laying in poultry has been improved through selection to increase the total number of eggs laid per hen. Studies have been published on egg production in Japanese quail. Production performance of the Japanese quails can be improved by increasing their genetic potential and favorable management conditions. Quail meat is preferred to chicken meat because of its less fat content (low calorific value), taste and delicacy. It demands a little resources to produce more quail meat in a shorter period. It can be achieved by a specific selection program for higher body weight at specific age (Kumar *et al.,* 2000). Short-term experiments can be used to estimate genetic variances and covariance, test their consistency from different sources of information, and estimate the magnitude of the initial rates of response to selection (Jaap, 1963; Siegel and Dunnington, 1987). Selection experiments for body weight may provide the framework for the study of the inheritance of

complex traits and allow the evaluation of theoretical predictions by testing observations against expectations (Jaap, 1963; Siegel and Dunnington, 1987).

2.2 Sexual Maturity Characteristics of Female Japanese Quail

Reddish *et al.* (2002) and Oruwari and Brody (1988) stated that there are relationships between chronological age, body weight, body composition and sexual maturity which are complex processes in determining body weight of traits within generations or lines. Magda *et al.* (2010) stated that the age at sexual maturity differed significantly among generation being 56.04, 54.38, and 45.58 day, for base, second and third generations, respectively. Similar values were reported by Lilburn and Nestor (1994) and Wilson *et al.* (1962), but less value of 48.7, 49.6 and 45.2 day than the age reported by Gebhardt-Henrich and Marks (1995), Gildersleeve *et al.* (1987), Darden and Marks (1988); El-Ibiary *et al.* (1966) and Cerit (1997). Reddish *et al.* (2002) and Oruwari and Brody (1988), stated that chronological age alone is not a primary effectors of sexual maturity but other factors such as enviromental,factors may have contributed too.

2.3 Sexual Mayurity Characteristics of Male Japanese Quail

Reddish *et al.* (2002) and Oruwari and Brody (1988), reported that lean body weight is not critical for initiation of selection in sexual maturity. Abdominal fat pad weight, however, when expressed as the absolute weight or as a percentage of body weight, was significant with sexual maturity in the generations. They stated that there is a minimum body fat threshold needed for sexual maturity in male quails. Other similar studies (Zelenka *et al;* 1984; Yannakopoulos *et al.* 1995) showed that fat deposition is an important factor in the process of sexual maturation. This same relationship was observed in selection for high body weight by Akbas *et al.* (2004) which suggested that selection for body weight increases the

complexity with respect to the mechanisms needed to initiate sexual development in females and males Japanese quail. Due to selection for high body weight, quail would reach their adipose threshold well before other physiologic systems involved in sexual maturation which reach the minimal stage of development needed for the onset of egg production. This is consistent with the concept of multiple thresholds (Reddnesh *et al.* 2002; Zelenka *et al.,* 1984) in which body weight and selection aspects of body composition must exceed a threshold value in order for sexual development to proceed (Dunnington and Siegel, 1984; Soller *et al.,* 1984).

2.4 Carcass Traits of Japanese Quail

The percentages of carcass components were higher in females than males in Japanese quail (Minvielle *et al.,* 2000; Vali *et al.,* 2005; Saatci *et al.,*2006; Shokoohmand *et al.,* 2007; Khaldari *et al.,*2010; Narinc *et al.,* 2010). The large reproductive organs in females, such as ovaries and oviducts, appear to be the main reasons behind higher body weight in females than males (Marks, 1993) apart from abdominal fat which as percentage of body weight is also greater in females (Fisher, 1984). Leenstra *et al.* (1986) also found that between 3 and 10 weeks of age, fat made from 10 to 19% of body weight in females, whereas it increased from 10 to 13% in males. Vali *et al.* (2005) reported that females (41.55%) had significantly higher breast percent of bodyweight than the males (41.65 vs 38.98%). However, Yalcin *et al.* (1995) reported that the difference between the females (30.6%) and males (32.1%) for breast as percent of body weight was not significant. Genchev and Mihaylov *et al.* (2008) and Aksit *et al.* (2003) also reported that the differences between sexes in respect to breast percent of body weight was not significant.

Other similar findings (Nestor and Bacon ,1982) indicated that selection for 4 to 7 weeks males-body weight over seven generations resulted in 6, 10, 11, 11, 19, 20 and 36g increament in body weight per generation, respectively. Tozluca (1993) also reported from a selection experiment that the increase in 4-weeks Body weight was 18.95g for males and 20.37g for females. Oguz and Turkmut (1999) and Baylan and Uluocak (1999) and obtained similar results of 18.72 in maales and 20.48g in females related to body weight increase. Vali *et al.* (2005) reported that there was no significant difference between the sexes in terms of drum + thigh as percent body weight. In contrast, Genchev *et al*. (2008) reported significant difference between the sexes with respect to relative proportion of thigh weight.

2.5 Bodyweight and Some Parts of Japanese Quail

Vali (2006) reported that body weight at 56 days of age in Japanese quail was 211.27 $\pm$ 2.38g. Vali (2006) also stated that, body weight of females at day 42, 56 and 63 of age were significantly higher than males, but there were no significant differences between males and females at at day 42, 56 and 63 for body weights in second experiment for body weight. The average shank, thigh and keel lengths reported by Kumar *et al.* (2000) at 28d and 42d of ages indicated that females had longer shank length than males at 28 days of age by 0.04cm, 0.04cm, 0.03cm and 0.04cm , respectively, in base population, S_1, S_2 and C groups of first generation (G_1). The respective corresponding increase at the 6^{th} week of age was noted as 0.08cm, 0.05cm, 0.07cm and 0.06cm. Thighs were also longer in females in all the groups and in both sexes at day 28d and 42d of ages, respectively. The average thigh length of females at 28 days of age in base population, S_1, S_2 and C groups were significantly longer than males by 0.04cm, 0.04cm, 0.03cm and 0.03cm, respectively. Kumar (2000) stated a corresponding increases in thigh length at 42d of age in similar groups as 0.05cm, 0.07cm,

0.07cm and 0.05cm. On the average females, keels were longer in females than males by 0.03cm, 0.04cm, 0.04cm and 0.03 in base, S_1, S_2 and C groups respectively at 28d of age. However, the corresponding increase among females at 42d of age were observed to be 0.09cm, 0.04cm, 0.06cm and 0.05cm, respectively. Mandal *et al.* (1994) observed an increase of 0.09cm, 0.22cm and 0.11cm in average shank, thigh and keel lengths, respectively at 28d of age in females over males in females over males. The higher values reported by Mandal *et al.* (1994) in relation to this study might be attributed to the difference in the genotype between males and females Japanese quail.

2.6 Egg Weight and Yolk Characteristics of Japanese Quail

The least –squares means for egg weight at for day 35, 42, 49 and 63 day values were 8.1g, 8.3, 9.6 and 12g, respectively (Song *et al.*1999). Oroian *et al.* (2002) and Kul and Seker, (2004). The values were higher than those reported by Chaudhary *et al.* (2001), Nazliqul *et al.* (2001) and Dhaliwal *et al.* (2004), Akpa *et al.* (2006) and Punya- kumari (2007) at day 35, 42, 49 and 63 days of age. Song *et al.* (1999) reported means for yolk weight to be 3.25g.

2.7 Egg Weight and Albumen Characteristics of Japanese Quail at Different Generations

Studies Song *et al.* (1999) and Akpa *et al.* (2006; 2008) on albumen weight revealed characteristics value ranging between 5.8 and 6.33g.The values reported were higher than those reported by Altinel *et al.* (1996); Chaudhary *et al.* (1999), Nazliqul *et al.* (2001); Oroian *et al.* (2002); Dhaliwal *et al.* (2004); Kul and Seker, (2004) and Punya-kumaris, (2007).

2.8 Egg Production and Weight Traits in Japanese Quail

Woodard *et al.* (1967), studied the challenges in production qualities along with aging in quail. They reported that egg production decreased after 26 weeks of age Janda (1977) in a similar study reported that there was a rapid decrease in egg production after 14 months and therefore advised for flock recycling at 13 months. Gildersleeve *et al.* (1987) reported that the daily egg production rate peaks at 9 weeks after the start of egg production and remains at greater than 80% until the 20^{th} week. Sundarama (1989) having examined the egg production qualities, reported the annual average egg production as 290 eggs, while Cerit (1997) reported 282 eggs.

2.9 Effect of Age and Sex on Live Body Weight and Carcass Traits in Japanese Quail

Singh and Panda, (1981) and Mousa, (1993) studied live body weight at week 6 in Japanese quail and found that the male average live body weight in male was 123.0 and 134.4g in female. Ajay-Kurma *et al*. (2000) stated that the means of various economic traits in different lines of Japanese quail showed that females were significantly heavier in body weights than males by 2.48g, 4.11g, 4.39g and 5.53g at 3^{rd}, 4^{th}, 5^{th}, and 6^{th} weeks of age, respectively.

2.10 Slaughter Weight and Carcass Percentage Characteristics of Japanese Quail

There are a lot of studies on the line of Japanese quail and results show that they have significant effect on body weight for both sexes. The females showed a higher body weight than the males (Minvielle, *et al.* 2000; Baumgartner, 1994; Toelle, *et al.*1991; Caron and Minvielle, 1990; Tserveni-Gousi and Yannakopoulos, 1986; Kawahara, and Saito, 1976). Line and sex of Japanese quail have significant effect on the carcass weight which females

having higher carcass weight than males. However, sex as reported had significant effect on the carcass yield and the males had higher carcass yield (71.2%), than the females (63.1%), as reported (Sezar *et al.,* 2010; Minvielle, *et al.* 2000; Caron, *et al.,* 1990). However, Minvielle, *et al.* (2000) also reported carcass yield values of 75.47% for females and 73.47% for males. El-full *et al.* (2001) found that live body weight of Japanese quail slaughtered at 5 weeks of age was 155.2g; it was increased to 190.9g for birds slaughtered at 7 weeks of age

Vali *et al.* (2000) reported carcass weight for body weight in female quails at day 35, 42, 49 and 63 to be 133.32, 160.59, 187.13 and 213.32g, respectively, while the respective values in males were 128.12, 150.96, 167.78 and 177.94g. Related report by Shrivastav and Panda (1991) showed that liver weights for males and females at 42 days were 5.5 and 9.2. Yalcin *et al.* (1995) found that sex had a significant effect on the weight of liver, which was greater for females than males (4.3 and 3.9g, respectively). Mohammed (1990) reported that giblet weight (intestine, liver, heart and lungs) and its percentage to live weight obtained during winter ranges between 10.3 and 11.6g. Bacon and Nestor (1983) investigated the weight of edible viscera in Japanese quail (heart, liver and clean gizzard) and found that carcass weight and all carcass composition were influenced by live body weight. The edible parts contained heart, liver and gizzard which were estimated at 1.3, 2.9 and 4.1g, respectively, at 5 weeks of age.

2.11 Effect of Sex and Age on Carcass Weight and Some Internal Organs in Japanese Quail

Jones *et al.* (1979) reported an estimate of 113.6g for carcass weight of Japanese quail slaughtered at 9 weeks of age without neck and shank. Chidananda *et al.* (1986) found that the significance of meat to bone ratio in Japanese quail was apparent as birds advanced in

age; the meat to bone ratio at 8 weeks of age (4.1%) was statistically not significant from those at 7, 9 and/or 10 weeks of age (5.0, 4.6 and 4.40%, respectively). Bacon and Nestor (1983) investigated the weight of edible viscera in Japanese quail (heart, liver and cleaned gizzard) and found that carcass weight and all carcass composition was influenced by live body weight. Sharaf and Mandear (1994) estimated carcass weight and giblet weights as 90.4 and 64.3gm in Japanese quail slaughtered at 6 weeks of age. Jones and Hughes *et al.* (1979) reported an estimate of 113.6g for carcass weight of Japanese quail slaughtered at 9 weeks of age without neck and shank.

2.12 Slaughter Age and Sex on Carcass and Some Inedible Traits in Japanese Quail

EL-full *et al.* (2001) found that live body weight of Japanese quail slaughtered at 5 weeks of age was 155.2g but increased to 190.9g for birds slaughtered at 7 weeks of age. The inedible parts consisting of the blood, feather, head, leg and neck were estimated as 4.8, 6.6, 4.2, 2.3 and 4.2g at 5 weeks.

2.13 Effect of Age and Sex on Carcass and Live Body Length at Different Generations of Japanese Quail.

The increase in average body weight in the females over males were reported to be 1.55g at 4 weeks of age by Ghany *et al.* (1996), 9.3g at 6 weeks of age by Sato *et al.* (1974), 1.12g, 2.82g, 5.20g and 8.71g at 3,4,5 and 6 weeks of ages, respectively (Prakash-Babu *et al.* 1980) and 2.3g at 6 week of age (Thomas *et al.*1996).

Ajay- Kumar *et al.* (2000) reported on the average shank, thigh and keel Length at 4 and 6 weeks of age. It was observed that females had significantly longer shank length over males at 4 weeks of age by 0.04cm, 0.03cm and 0.04cm respectively in base population, S_1, S_2 and C groups, in the first generation. The corresponding increases at 6 weeks of age were

noted as 0.08cm, 0.05cm, 0.07cm and 0.06cm. Average female keels bone length were significantly longer by 0.03cm, 0.04cm, 0.04cm and 0.03cm than males in base S_1, S_2 and C groups respectively at 4 week of age. The corresponding increases among females at 6 weeks of age were observed to be 0.09cm, 0.04cm, 0.06cm and 0.05cm, respectively Mandal *et al.* (1994) observed 0.11cm as in keel length at 4 weeks of age.

2.14 Effect of Age and Sex on Live Body Weight and Dimensions at Different Generations In Japanese Quail

Prakash-Babu *et al.* (1980), Arjun Kumar *et al.* (1990), Praharaj *et al.* (1990), Shrivastav and Panda, (1995) and Shokoohmand *et al.* (2007) reported lower body weights at the same ages. The average shank and thigh lengths at 4 and 6 weeks of ages were studied by Ajay-Kumar *et al.* (2000) who observed that females had significantly higher shank length over males at 4 weeks of age by 0.05cm,0.05cm, 0.04cm and 0.05cm, respectively in base population, S_1, S_2, and C groups of the first generation. The corresponding increases at 6^{th} week of age were noted as 0.09cm, 0.05cm, 0.08cm and 0.07cm. Thighs were also longer in females in all the groups both at 4 and 6 weeks of age. The average thigh length of females at 4 weeks of age in base population, S_1, S_2, and C groups were significantly longer than males by 0.04cm, 0.04cm, 0.03cm and 0.03cm, respectively. The corresponding difference increases at 6 weeks of age were noted as 0.01cm, 0.04cm, 0.01cm and 0.02cm.

Body weights of Japanese quail at 35, 42, 49 and 63 days showed that body weight at day 35, 42 and 49 differed significantly except at day 63 (Vali *et al.* 2006). further–more studies conducted on sex of Japanese quail at day 35, 42,49 and 63 showed that females have higher body weight than males (Kawahara and Saito, 1976; Caron and Minvielle, 1990; Toelle *et al.*, 1991; Baumgartner; 1994; Minvielle *et al.*, 2000).

2.15 Effect of Age and Sex on Breast Meat Acidification in Japanese Quail

Riegel *et al.* (2003) stated that in freshly slaughter birds, meat pH is near to the neutral but when rigor mortis occurs, it decreases to 6.02-6.11. Breast mean pH at the 20th minute post mortem (pH_{20}) ranged between 6.2-6.36. They also observed that muscle tissue contains about 75% water but only 10-15% of it is chemically bound to proteins. The other amount is retained by the spatial structure of proteins as "free water". Therefore, Water Holding Capacity (WHC) is the highest immediately after slaughtering, prior to rigor mortis occurrence (Valkova-Yorgova *et al.,* 2000). After rigor mortis resolution, the WHC of meat is reduced. Several re ports have provided evidence for water losses in Japanese quail meat to vary from 28 to 33.9% (Baumgartner *et al.,* 1987; Drbohlav and Metodiev, 1997). Low meat pH values decreases the WHC and tenderness of meat and increases the cooking loss percentage (Northcutt, 1994; Van-Laack, *et al.,* 2000). According to most investigators, meat pH is not sufficient to characterize meat quality as meat technological properties are largely dependent on colour characteristics of breast meat, its structure and water holding capacity (VanLaack *et al.,* 2000; Qiao, *et al.,* 2001; Barbut *et al.,* 2005; Fraqueza; 2000; 2006; Lonergan, *et al,* 2003; Owens *et al.,* 2000).

2.16 Effect of Age and Sex on Breast Meat Colour in Japanese Quail

Riegel *et al.* (2003) stated that meat colour depends on numerous factors, including the proportion of tissue that builds up the muscles. The higher tenderness of the pectoral muscle in female quails could be attributed to the slightly higher percentage of dark muscle fibres, whose diameter is smaller than that of light ones (Riegel *et al.* 2003; Van Laack, *et al.* (2000), as well as to the higher content of connective and especially intramuscular fat tissue (Valkova- Yorgova *et al.,* 2000).

The high relative proportion of oxidative type muscle fibres in breast meat of quails influences positively the other two colour characteristics, redness(a*) and yellowness(b*) (Riegel *et al.*2003). The values obtained for Japanese quail breast meat range from 10.9 to 12.4, and are considerably higher than values obtained in broiler chickens – from 2.2 (Allen, *et al.*, 1997) to 5.45 (Qiao, *et al.*,2002) and in turkeys: 4.9-5.5. Fraqueza, *et al.(*2006). Qiao, *et al*, (2002) found significant differences in breast meat colour in the red/green and yellow/blue spectra between Japanese quails vs chickens and turkeys thus they attributed to the different morphological structure of the pectoral muscle. The dark muscle fibres, rich in myosin that build up the breast muscles in Japanese quails, give a more saturated colour in both the red and yellow zone of the spectrum. Sex-related differences of average values was 5%. The coordinates in the red/green spectrum (a*) varied from 5.1 to 14.4, and in the yellow/blue spectrum (b*) – from 7.9 to 13.4. Breast meat redness and yellowness accounted for the excellent chroma (15.09±0.15) of the meat of the studied Japanese quail breed. With advancing slaughter age in males, a tendency towards increased chroma of meat from 14.6±0.4 to 16.2±0.4 was observed. In females, age-related changes were not demonstrated. At the age of 35 days, the pectoral muscle of Japanese quails was composed from 95.7-96.4 % dark muscle fibres. The percentage of light muscle fibres varied within 2.9 and 5.2%. In male quails, pectoral muscle was built from 98.37±0.18% muscle tissue, 1.36±0.14% connective tissue and 0.28±0.05% intramuscular fat tissue. In female quails, the respective values were 97.61±0.20%, muscle tissue, 1.79±0.22%, connective tissue and 0.59±0.04% intramuscular fat tissue.

2.17 Rate of Genetic Improvement from Selection for Body Weight and Shank length

Ajay Kumar *et al.* (2000) stated that females were significantly heavier in body weight than males by 2.48, 4.11, 4.39 and 5.53g at 2.1, 28, 35 and 42 days of age, respectively, in the base population. The increase in average body weight in females over males which were reported to be 1.55g at 4 weeks of age by Ghany *et al.* (1996), 9.3g at 6 weeks of age by Sato et al. (1974), 1.12, 2.82, 5.20 and 8.71g at 3, 4, 5 and 7 weeks of age, respectively, by Prakash-Babu *et al.* (1980) and 2.3g at 7 weeks of age by Thomas *et al.* (1996).

In a growth rate study in Japanese quail by Balcioglu *et al.* (2005), it was reported stated that growth rate in all the Japanese quail lines was significantly higher in males than in females. There was however a significant increase in growth rate of the females selected for increased 5-week body weight over the control females, as well as a significant decline in growth rate of males selected for decreased 5-week body weight compared to unselected control group in Japanese quail.

2.18 Genetic Improvement of Male Sexual Reproductive Traits

Hussien *et al.* (1996) reported that an increase in continuous selection for a traits indicated that there was a remarkable improvement of those various traits. The genetic improvement traits of the reproductive and egg in female Japanese quails were affected by different factors such as: mating ratio, parental age, rate of laying, climatic and managerial conditions (Narahari *et al.*, 1988).

2.19 Genetic Improvement of Some Reproductive and Egg Traits in Japanese Quail.

Studies by Saatci *et al.* (2005) showed that increase in body weight led to decrease in egg number as a result of several factors such as age at sexual maturity, managerial and climatic conditions.

Sachev *et al.* (1995) reported that ASM in selected line for body weight at 4 weeks of age and control line of European quail to be 71.6 $\pm$ 3.1 and 71.8 $\pm$ 2.4. Hussien *et al.* (1996) reported the results of continuous selection that showed marked improvement of the various traits and stated that after 10 generations of selection, improvement in body weight caused sexual maturity to delay by 3 days. Japanese quails were divergently selected for 5-week body weight over 5 generation by Ina *et al.* (1996) with a random bred line maintained as a control; they found the that, ages at 1st egg were 39.83 to 45.84, 42.10 to 51.10 and 40.11 to 46.05 days in selected and control line, respectively. Falconer, (1989) investigated the effect of inbreeding on the initial and the next 3 generations; and observed age at the first egg was 51.5 days for the experimental groups and 54.6 days for controls. Marks (1975), in a random bred population of Japanese quail observed body weight at hatch to range from 6.3 to 6.6g. Higher estimates were reported for two sexes by Marks (1996) as 8.8g. Marks (1990) and Oguz *et al.* (1996) reported higher estimates for these traits to be 9.3g for lines selected for high body weight. Aboul-Hassan (1997) reported BW_0 as 8.6 and 8.3g for female and male sexes respectively.

Falconer (1989) conducted a study on to determine the egg fertility for 4 generations Japanese quail selected under experimental and control line.The result of control line showed that generation 1, 2, 3 and 4 showed egg fertility of 71.0, 81.4, 64.9 and 76.6% , respectively while for the experimental line were 84.0, 79.5, 75.9 and 74.2% for controls, respectively.

Noda *et al.* (2003) reported that egg hatchability for quails selected for egg production (Line E) or body weight at 5 weeks (Line M) for over 20 generations were 67.3 and 56.7% Vs 66.7 and 71.3% in 4 lines. A total of 256 quails were reared under each system in each season for Hen-day egg production which percentages hatchability being higher under pair- mating than under flock mating (75.29 vs 60.32%) and (70.91 vs 49.51%)..

2.20 Genetic Improvement in Egg Quality Traits

Egg quality is component of those characteristics of an egg that affect its acceptability to consumers (Stadelman,1977). Among many quality characteristics that improve eggs acceptability by consumers are cleanliness, freshness, egg weight and shell quality. Song *et al*. (2000) stated that selection for body weight improved the egg albumen content of moisture (87.46 – 87.99%), crude fat in albumen (0.09-0.13), yolk content (49.71-50.42%), high levels of fat in yolk (31.48-32.32%) and crude protein (15.12 – 15.99%).

2.21 Genetic Improvement of Body Weight at Different Ages of Growth

Kesici *et al.* (1998) selected Japanese quail for high 5-weeks BW and found that there was genetic improvement in the 1st generation of selection. Turedi and Duzgunes (1984) reported that body weight increased by 5.25g in selection based on 6-weeks BW. Similar results for BW increases were reported by Marks (1980, 1996). Collins and Abplanalp (1967) reported that the BW of quail selected for 6-weeks BW was 20g higher than the base population. Nestor and Bacon (1982) reported 7 generations of selection for 4-weeks BW produced an increase of 6, 10, 11, 11, 19, 20 and 26g per generation, respectively. Tozluca (1993) also reported that the increase in 4-week BW was 18.95g for males and 20.37g for females. Oguz and Turkmut (1999) and Baylan and Uluocak (1999) obtained similar results related to BW increase, but they obtained negative values for some groups.

2.22 Response to Genetic Improvement of Carcass Weight at Different ages of Growth in Japanese Quail

The genetic improvement of carcass weight at different ages of growth in Japanese quail shows that there was improvement in the carcass weight by 60% as stated by Singh *et al.* (1981)..

2.23 Heritability Based on Individual Selection for Body Weight in Japanese Quail

The study of Baylan *et al.* (2009) indicated that the realized h^2 for body weight (BW) after selection for 2 generations was higher than in the first generation. Magda *et al.* (2010) reported that h^2 estimate increased with generation of selection to the 3rd generation.

A wide range of h^2 estimates for body weight has been reported at different ages, used different methods to estimate the heritability (Tish *et al.,* 1997; Kumar *et al.,* 2001; Saatci *et al.,* 2002; Vali *et al.,* 2005; Baylan *et al.,* 2009; Akbas *et al.,* 2004) and generations (Baylan *et al*., 2009; Baylan and Uluocak 1999; Magda *et al.,* 2010).

The heritability estimates based on individual selection for body weight for Japanese quail in selected generations for h^2_S, h^2_D and h^2_{S+D} were 0.20, 0.45 and 0.32, respectively when selection was applied for BW_6 (Aboul-Hassan, 1997 ; El-Fiky, 2005).

2.24 Heritability Estimates of Body Weight at Different Ages of Growth Japanese Quail

The heritability value for BW at day 35, 42, 49, 56 were 0.58, 0.71, 0.24 and 0.25 as stated by Sefton and Siegel, (1974) , El-Fiky *et al.* (1994), Aboul-Hassan, (2000) and Abdel-Mounsef (2005), respectively. Similarly, Minvielle (1998) reviewed reports from several studies and stated that heritability estimates for body weight of Japanese quail at 4 and 8 weeks of age were 0.47 and 0.74, respectively. Lower estimates for body weight at 35 days

of age (BW_{35}) and body weight at 42 days of age (BW_{42}) were estimated as 0.30 and 0.25, respectively by Vali *et al.* (2005). Collins and Abplanalp, (1965) and Collins *et al.,* (1968) found a realized heritability estimate of 0.14 for 8 weeks body weight. The uniqueness of the population, the selection environment, and the period or length of selection (generations), all can have a pronounced effect on the magnitude of the heritability estimates. Although these estimates indicated considerable variation, heritability for body weight in Japanese quail appeared to fall within the range of heritabilities found for body weight in chickens 0.2 – 0.4 (Siegel, 1962; Kinney, 1969; Siegel and Dunnington, 1987 and Saatci *et al.,* 2002).

The $h^2$of body weight reported by Adeogun and Adeoye (2004) ranged between 0.42 to 1.08. Akbas *et al.* (2004) and Baylan *et al.* (2009) estimates $h^2$for body weight at different ages to increase from week 1 to 5 and then decreased thereafter.

Also, Falconer, (1960) reported that h^2 for a particular trait can take different values according to the population, environmental conditions surrounding the animals and the calculation method. Some researchers reported negative values for h^2 posibly because of population size (Kacak *et al*.,1995, Nestor *et al.,* 1995; Baylan 2003), while others reported moderate h^2 for body weight at various ages of growth (Tigali *et al.,*1997; Saatci *et al.,* 2002; Akbas *et al.,* 2004 and Shokoohmand *et al.,* 2007). The differences in the h^2 estimates might be attributed to method of estimation, strain, environmental effects and sampling error due to small data set or sample size (Prado-Gonzalez *et al.,* 2003).

2.25 Heritability Estimates of Female Sexual Reproductive Traits

El-Fiky *et al.* (2000); Aboul-Hassan (2001); Abdel-Mounsef (2005) and Sezer *et al.* (2006) reported heritability of age at sexual maturity in female Japanese quail at day 35, 42,

49 and 63 to be 0.18, 0.11, 0.30 and 0.33, respectively. Abdel-Mounsef (2005) and Sezer *et al*. (2006) reported heritability (h^2) estimates for female age at sexual maturity (ASM) to be 0.30 and 0.33, respectively. However, El-fiky *et al.* (2000) and Aboul-Hussan (2001) reported the value of age at sexual maturity for female as 0.19 and 0.11, respectively.

2.26 Heritability Estimates of Male Sexual Reproductive Traits

The heritability estimates for male reproductive traits by Marks and Kinney (1964), El-Fiky (1991), Bahie El-Deen,(1994); Shebl *et al.* (1996) and Sezer.*et al.* (2006) for age at sexual maturity were be 0.48, 0.42, 0.31, 0.28, and 0.24, respectively. While Marks and Kinney (1964); Wilhelmson, (1979); Bahie El-Deen, (1991) stated the heritability value higher. The h^2 value for age at sexual maturity for males were 0.31, 0.28 and 0.24 as reported by El-Deen (1994), Shebl *et al.* (1996) and Sezer *et al.* (2006), respectively. However, the value of Age sexual maturity for males was 0.42 as reported by El-fiky (1991). Magda *et al.* (2010) and Bahie El-Deen *et al.* (2008) reported that h^2 for age at sexual maturity ranged from 0.07 to 0.44, respectively.

2.27 Heritability Estimates of Egg Quality Traits in Japanese Quail

Sezer, (2007) stated that heritability estimates of egg weight, egg width, egg height, shell thickness and shell weight were 0.83,0.68,0.72,0.53 and 0.08, respectively. Saito *et al.* (1989) stated that heritability estimates of egg characteristics were high and ranged from 0.02 to 0.84. The result indicated that individual selection should be the most efficient method of improving egg characteristics and that consideration should be given to the interrelationships of characteristics to accomplish genetic improvement because of their genetic merits.

2.28 Heritability for Egg Production in Japanese Quail

Abdoul-Hassan (1995); Helal (1995); Abdel-Mounsef (2005) and Tawefeuk (2001) reported heritability estimates for egg production (number and weight) at different periods of laying in quail to be 0.31, 0.57, 0.75 and 0.46 for day 35, 42, 49 and 56, respectively. The heritability (h^2) estimates for egg weight reported by Kacak *et al.* (1995) and Saatci *et al.* (2005) were 0.48, 0.48 and 0.25, respectively, Francesch *et al.* (1997) reported the range to be 0.48 to 0.59. Saatci *et al.* (2008) reported h^2 of egg length and egg width to be 0.18 and 0.22, respectively. Saatci *et al.* (2005) reported low h^2 for egg quality characteristics (0.18 to 0.22. The values of h^2 estimates for egg weight (0.69), egg width (0.61), egg height (0.51), shell thickness (0.75) and shell weight (0.60) in this study are comparable to the values of egg weight (0.83), egg width (0.68), egg height (0.72), shell thickness (0.53) and shell weight (0.08) reported by Sezer (2007).

2.29 Heritability Estimates of Carcass Weight at Different Ages of Growth in Male Japanese Quail

Kawahara and Saito (1976), El-Fiky (1991), Mousa (1993), El-Full *et al.* (2001) and Abdel-Mounsef (2005) reported heritability estimates for carcass traits in Japanese quail to range from 0.06 to 0.78. The observed increase in the h^2 estimates of carcass weight with age indicated that the genetic variance increased considerably with increment in age of the birds (Akbas *et al.,* 2004). Vali *et al.* (2005) reported h^2 for carcass weight of 0.43 for Japanese quails. Other researchers reported moderate to high h^2 for carcass traits in Japanese quails (El-Fiky, 1991, Mousa.,1993; El-Full *et al.*, 2001 and Mounsef, 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at the Poultry Unit of Animal Science Department, Faculty of Agriculture, Ahmadu Bello University, Samaru –Zaria. Zaria is within Northern Guinea Savannah zone of Nigeria, latitude 11' 12°N and longitude 7' 33°E at an altitude of 610M above sea level. The climate is relatively dry, with mean annual rainfall of 700-1400mm, occurring between the Month of April and September. The dry season begins around the middle of October, with dry cold weather that ends in February. This is followed by relative hot, dry weather from March to April, when the rain begins. The mean minimum and maximum daily temperature is about 14° and 24°C during the cool season and 19° and 36°C during the hot season. The relative humidity varies between 19% in the dry season and between 63% and 80% in the wet season as stated by Akpa *et al., (2002*).

3.2 Mating Plan

Artificial selection was carried out on the birds at day 35, 42, 49 and 56 after weighing all the birds. Those with the highest weight were chosen for breeding consisting of 50 males and 150 females. The selected birds were mated in a constructed cage at the ratio of 1 male to 3 females (1:3) in constructed caged of 10cm x 10cm x 10cm to determine the BW, carcass weight, Body Length traits, minerals and chemical composition of meat. Mating ratio in separate caged of 1:1 was used to determine Age at sexual maturity in females and males, egg quality and egg production in the two generations. For the study that utilized mating ratio 1:3, all the birds were wing banded in accordance with the families and 1500 fertile eggs were hatched.

3.3 Management of Fertile Egg

Eggs were collected daily after the birds had reached maturity, as from at each of day 35, 42, 49 and 56 days of age. Eggs were identified by their sire families (28), stored at room temperature lower than 20°C and 65% relative humidity (RH) for a week, and then disinfected with tetra hydroxyl (TH4) mixed with 1 liter of water for spraying on egg surface. Pedigreed eggs were set in the setting trays, depending on their sire families and arranged in a forced draft incubator with temperature of 37.5°C and 65% RH. Eggs were turned automatically every three hours. At the end of the 14th day of incubation, eggs were transferred into pedigree hatching baskets and moved into the hatcher where the temperature was 37.5°C and RH was 70%.

3.4 Incubation and Hatching of Fertile Eggs

Pre-incubation of the fertile egg collected was made by storing them at a temperature of 15°C. Fumigation was done 12 hours before placing them in the incubator. When eggs were set in the incubator, temperature requirement was put at 37.5 °C with humidity of 60% and turning of eggs was at an angle of 45° for 4-6 times a day and the chicks were hatched at day 18 of incubation.

3.5 Experimental Birds and their Management

The research work started with a foundation stock of 784 Japanese quails at 21 days of age, purchased from National Veterinary Research Institute (NVRI), Vom, Plateau State. The management of the young chicks included the provision of supplementary heat for 4 weeks under 24 hours lighting, and thereafter 13 to 16 hours light and 6 to 8 hours dark cycle. Indoor air temperature for the chicks was 36 °C. Birds were allowed *ad libitum* access to food and water. They were fed with starter and grower diet containing 24% crude protein

(CP) and 2904ME, Kcals/kg between 1-35 days of age. Thereafter a breeder diet containing 23% CP and 2800, Kcals/kg ME was fed. The same diets were provided to birds on the selection process across various generations. The minerals and vitamins were adequately supply to cover the requirements according to NRC (1994).

3.6 Data collection

Three generations namely base population, G_1 and G_2. The following data were collected on each generations:

3.6.1 Body Weight

Seven hundred and eighty four birds were used to study the body weight (g) traits of the birds. The birds were sexed at day 21 at which point they were feathered. The birds were housed in 56 constructed cages with 28 cages each for male and female quails, and each cage housed 15 quails.The dimension for the cages was 60cm × 45cm × 45 cm (length breath height). The birds were separated by sex to avoid indiscriminate mating. Three (3) birds from each cage were randomly picked at day 35, 42, 49 and 56 in each generation G_0, G_1, G_2 to determine the live body weight (g) respectively.

3.6.2 Measurement of the Live Body Changes (g):

After sexing at day 21, 28 male and 28 female birds from both the parents of base generation$_0$ (G_0), Generation$_1$ (G_1) and Generation $_2$ (G_2) each at day 35, 42, 49 and 56 were randomly selected and body weight increment recorded for each generation and the record were used to estimate growth rate. The increase in body size was measured to the nearest 0.1g.

3.6.3 Sexual Maturity

One hundred chicks from base generation (G_0) at 21 days of age were feather sexed and the males separated from the females. Paired mating was used to obtain G_1 and G_2. After sexing at day 21, the birds were housed separately in a consructed caged size 5cm × 2.5cm × 2.5cm to monitor sexual maturity using 50 females and 50 males the monitoring started and at day 35. They were monitored for females, when they dropped the first egg and males when they produced the first proctodeal gland. Monitoring was from 07.00 to 11.00am and 01.00 to 05.00pm (8hours) daily. At sexual maturity the following traits were measured: Body weight at 35d, age, body weight (g), egg weight, follicle number (n), follicle size (cm), oviduct weight (g), pectoral major weight (g) and abdominal fat weight (g) for the females. In the male, sexual maturity traits determined were: Body weight at 35d, age, body weight (g), testicular weight (g), pectoral major weight (g), abdominal fat weight (g).

3.6.3.1 Female Sexual Maturity Traits

These were determined as follows:

Body weight at day 35(g): The weight of birds taken at 35 day of age.

Age (d) at sexual maturity: The age at which the first egg was laid.

Body weight (g) at sexual maturity: Weight of birds at first egg.

Egg weight (g) at sexual maturity: Weight of each first egg laid measured by using a digital weighing machine.

The birds were sacrificed to determine the following:

Ovary weight (g): Weight obtained using digital weighing machine.

Follicle number (n) at sexual maturity: The number of yellow follicle present was observed compound microscope magnify × 40 and matured follicle counted.

Follicle weight (g) at sexual maturity: determine by measuring the length of the follicle using Vernier caliper

Oviduct weight (g) at sexual maturity: The oviduct weight was obtained using digital weighing machine.

Pectoral major (g): Obtained using digital weighing machine.

Abdominal fat weight (g): obtained by using digital weighing machine.

3.6.3.2 Male sexual maturity

This was determined as the period when the male first produced proctodeal gland foam.

The following measurements were taken at this point:

Body weight at day 35: The weight of birds determined when they were 35 days old.

Age (d) at sexual maturity: The age at the start of proctodeal gland production.

Body weight (g) at sexual maturity: Weight of bird at start of proctodeal gland foam Production.

The birds were sacrificed to obtain the following measurements:

Testicular weight (g) at sexual maturity: Weight of testes at start of proctodeal gland foam production.

Pectoral major (g): Obtained using digital weighing machine.

Abdominal fat weight (g): Weight known by using digital weighing machine.

3.6.4 Live Body Length Measurement (cm):

Seven hundred and eighty four birds used for Live body weight measurement and live body length measurement traits of the were taken on the 784 birds used in 3.3.1 measurements were taken after sexing at day 21 (point when birds were feathered).

Back length (cm): Obtained by using a cloth tape to measure from tail to the last cervical point of the neck.

Pelvis Width (cm): measured by using vernier caliper across the pelvis.

Breast Length (cm): Obtained by using a tailors tape, measured from the back bone to the last cervical vertebra round the body.

Shank Length (cm): Obtained by using a tailors tape from the hock joint to the base of the 3toes.

Drumstick +Thigh length (cm): Determined by using the tailors tape from the pelvis joint down through the thigh drumstick to the hock joint before shank.

Wing length (cm): Determined by placing tailors tape across from the tip to the point of attachment of wing to the body of the bird.

Abdominal fat circumference (cm): Vernier caliper was used to determine the thickness of the abdominal fat, corrected to the nearest 0.01mm.

Large Feather length (cm): Determined by placing tailors tape across the length of the wing.

Breast width (cm): Obtained by placing tailors tape round the body girth.

3.6.5 Carcass Trait Measurement :

Twelve hours prior to slaughter live weight (g), 56 birds were deprived of feed and after slaughter they were defeathered to determine the: Carcass Weight (g), dressing percentage (DP %), Head Weight (g), Leg Quarter Weight (g), Wings Weight (g), Internal Contents Weight (g), Breast weight (g), Drum stick+ Thigh weight (g), Neck weight (g), Back weight (g), Feather weight (g) and Shank weight (g).

The following carcass traits were measured to the nearest 0.1gm:

Live weight (g): The weight of each live birds was obtained before slaughter using digital weighing machine.

Carcass Weight (g): Determined as the difference between the live weight and the weight after bleeding, defeathering and evisceration.

Dressing percentage (DP %): Calculated using the following formula:

$$\mathrm{DP} = \frac{\text{Carcass}}{\text{Live body weight}} \times 100$$

Each carcass was cut into retails :

Head Weight (g): Determined by removing the head from the neck at the first cervical bone after birds were slaughtered and the weight measured.

Wings Weight (g): Determined after removing them from the body of the bird after birds were slaughtered and the weight measured.

Internal Contents Weight (g): Determined after slaughtering the birds the the were dissected and the weight of intestine, liver, heart, lungs, gizzard, kidney, testis and abdominal fat measured

Breast weight (g): Determined after slaughtered the birds the thigh, head, wing, back and neck were removed from the carcass and weight using digital weighing machine.

Drum stick + Thigh weight (g): Determined by placing the drum stick and thigh on digital weighing machine

Neck weight (g): Obtained after slaughtered using digital weighing machine.

Back weight (g): Weight of the back was measured on digital weighing machine.

Feather weight (g): After defeathering the weight of live bird was taken minus weight defeathering using digital weighing machine.

Shank weight (g): Separated at the hock joint and weight measured.

3.6.6 Body weight gain:

Daily body weight gain during the different growth periods after sexing from day 28 to 35, 35 to 42, 42 to 49, and 49 to 56 were calculated using the improvement body weight gain and percentage improvement body weight gain as follows:

$$\Delta Gg = \frac{W_2 - W_1}{W_1}$$

$$\%\Delta Gg = \frac{W_2 - W_1}{W_1} \times 100$$

Where:

$\Delta Gg =$ Improvement gain

$\%\Delta Gg =$ Percent of improvement gain

W_1 = Initial body weight, W_2 = Final body weight

3.6.7 Egg Production Traits:

Three hundred and ninety two females quails were distributed in to 28 cages constructed 60cm × 45cm × 45 cm (length breath height) to study the number of eggs produced in the morning and afternoon. The eggs produced in the morning were picked at 10.00am and afternoon at 4.00pm daily and result recorded per week. The following were determined:

Egg production/day/week: Determined by collecting and recording the egg collected morning and afternoon daily andsumming the total weekly.

Number of egg laid (n): Total number of eggs produced by the birds in a given period in a given generation..

3.6.8 Egg Quality Traits

Three eggs from each of the 28 cages housing 15 females each were randomly picked on a specific day of the week to determine the egg quality traits for each generation 0, 1 and 2 at day 35, 42, 49 and 56 for G_0, G_1, G_2. Each of the eggs picked was broken into a known weight of clean smooth paper that does not absorb liquid immediately and the following measurements obtained:

Egg weight (g): Weight of egg, known using digital weighing machine after breaking up.

Egg length (cm): Measured to the nearest 0.01mm, using vernier caliper

Egg width (cm): Determined using vernier caliper corrected to the nearest 0.01mm.

Yolk weight (g): Obtained by separating the yolk from the albumen and weight of yolk obtained using digital weighing machine

Yolk length (cm): Obtained by using vernier caliper, corrected to 0.01mm.

Yolk height (cm): determined using venier caliper, corrected to the nearest 0.01mm.

Albumen Weight (g): By separating the albumen from the yolk and weight of albumen obtained by using digital weighing machine.

Albumen Length (cm): Vernier caliper was used to obtain the length, corrected to 0.01mm.

Albumen Width (cm): was obtained by using vernier caliper across the yolk, corrected to 0.01mm.

Shell + Membrane Weight: The shell alone with membrane of each egg were collected and air dried for one hour and weight of each was determined.

Shell + Membrane Thickness: Micrometer screw gauge was used to determine the thickness of the dried shell +membrane corrected to 0.01mm.

3.6.9 Reproduction Traits:

About 1000 eggs were collected from mated birds of 1:3 male to female ratio in a cage from groups of 28 families on daily basis for 15 days for G_0, G_1 nd G_2. The collected eggs were stored in a cool room every 6 days of collection before setting them for hatching. The following measurements were made out of 362 females Japanese quail for each of G_1 and G_2 from the set eggs: Fertility, Hatchability, Number of Dead in shell and Dead embryos.

The following measurement were made:

Egg set: Total number of eggs set in an incubator

Fertility: Total number of eggs that were fertile from the set egg

$$\textbf{Fertility}\ \% = \frac{\text{Number of hatched chicks}}{\text{Number of fertile eggs}} \times 100$$

Hatchability = Total number of eggs that were hatch from the fertile egg

$$\textbf{Hatchability}\ \% = \frac{\text{Number of eggs hatched}}{\text{Total number of eggs set}} \times 100$$

Number of Dead in shell: number of fertile eggs that just started the process of development but immediately died in shell.

Dead embryo: The number of mature chicks that failed to hatch

Infertile egg: Number of eggs that did not hatch and after breaking showed no sign of development.

3.6.10 Quail Meat Proximate Composition:

Breast sample from 3 each from female and males birds were collected from breast portion weekly at day 35, 42, 49, 56 for G_0, G_1, G_2 after slaughter to determine moisture, protein, fat, ash, and NFE contents. They were determined in accordance with the standards of AOAC methods (AOAC, 2000). Protein determination involved a Kjeldahl assay (N x 6.25). Fat was determined by extracting samples in a soxhlet apparatus using petroleum ether as a solvent. Moisture was quantified by oven-drying 10g samples at 100°C over night. Ash was determined after incineration in a furnace at 550°C and carbohydrate content was calculated by computing the difference.

3.6.11 Mineral Composition of Quail Meat

Samples from 3 female and male birds were collected weekly at day 35, 42, 49, 56 for G_0, G_1, G_2 after slaughter to determine mineral elements content after drying and ashing of samples at 550°C and preparation of hydrochloric solution. The concentrations of K^+ and Na^+ were assayed on a flame photometer spectrophotometrically by the molybdate-vanadate method and the other elements such as Ca, Mg, Fe, Zn, Na, K and P were obtained by using the atomic absorption spectrophotometer.

3.6.12 Rate and the Intensity of the Muscle Acidification during Post mortem:

Physical and chemical traits from the left side of the breast sample was taken from the 10 male and 10 female birds at day 35, 42, 49 and 56 to determine breast muscle pH_{20min} (pH_{20min}) post slaughter and pH_{24hour} (pH_{24hr}) post slaughter. At the 24th *post mortem* hour, hydrophilic properties of meat were also determined as – water holding capacity (WHC) and water absorption capacity (WAC) and colour characteristics of the meat were determined:

The breast muscles pH was determined with ten female and ten male birds were slaughtered at day 35, 42, 49 and 56 after a 6-hour fasting period. After slaughter, evisceration and defeathering, pH_{20min} and pH_{24hr} values were measured with a pH meter, equipped with glass electrode and a temperature probe. The pH of a solution was taken the negative logarithm of the hydrogen ion activity determined in breast portion of meat using standard buffer solutions. They were prepared with carbon-dioxide-free water and stored in bottles of chemically resistant glass. The apparatus was calibrated with standard buffer solutions to check the linearity of the response of the electrode at different pH values and to detect a faulty glass electrode. The standardization of the apparatus was calibrated with two standard buffer solutions. After the apparatus has been calibrated, the electrodes and the cups were

thoroughly washed. The cup were fill with a portion of the solution tested and preliminary values were obtain before getting the actual value of the pH subsequently for each sample of day 35,42,49 and 56 for the two sexes.

Water Holding Capacity (WHC) was determined with ten samples of approximate size of 2.0x1.0x0.5 cm meat were obtained from the pectoral muscles. They were weighed with a precision of 0.001 g, and put in tubes containing 15 ml saline. Samples were left for 24 hours at about 2-40^{C}. After 24 h, meat pieces were removed from the tubes, carefully dried on a filter paper and again weighed on the same scales.

The WHC of meat was calculated as: WHC = $(b\text{-}a)\times\frac{10}{a}$

where: a – weight of the piece of meat prior to analysis(g), b - weight of the piece of meat after a 24-stay in physiological saline(g).

The Water Absorbing Capacity (WAC) of meat was determined in saline. Two samples of approximate size of 2.0x1.0x0.5 cm meat were obtained from the pectoral muscles. They were weighed with a precision of 0.001 g, and put in tubes containing 15 ml saline. Samples were left for 24 h at about 2-40^{C}. After 24 h, meat pieces were removed from the tubes, carefully dried on a filter paper and again weighed on the same scales.

The WAC of meat was calculated as: WAC = $(b - a)\ x\ 10 / a$ $(b\text{-}a)\times\frac{10}{a}$

where:

a – weight of the piece of meat prior to analysis, g;

b - weight of the piece of meat after a 24hr -stay in physiological saline, g;

The muscles colour was determined by taken a sample of sliced meat from the posterior part of the breast muscle was obtained from 10 female and 10 male Japanese quail after slaughter to determine the colour of muscles set-up a spectrophotometer produced by X-Rite incorporated. The values of L*, a* and b* colorimetric coordinates were determined on scale (Riegel *et al.*,2003):

L^*= corresponds to Lightness,

a^*= corresponds to Redness,

b^*= corresponds to yellowness

On the basis of a* and b* values were calculated as follows:

Chroma (C)=(a*^2+b*^2)^0.5 and the

Hue angle (h^o), that specifies the site of cross point of coordinates a* and b*: h^o=tg1(b*/a*)

3.7 Estimation of Genetic Parameters

3.7.1 Realized Heritability:

$$h^2 = \frac{\Delta G}{I}$$

ΔG = Response to selection, I= selection differential, $\Delta G = P_1 - P_0$

Where:

$\Delta \mathbf{G}$= Response to selection

P_1 =Mean body weight of offspring, P_0 =Mean body weight of parents(unselected) generation

Selection differencial:

$I = P_s - P_o$

I= selection differencial , P_s = Mean body weight of selected from population,

P_o = Mean body weight of population

Statistical analysis

Percentage fertility and hatchability were transformed to the corresponding arc sine values according to Snedecor and Cochran, (1981).

Statistical analysis was done by the aid of SAS software (SAS, 2004) according to the following Statistical models:

$\mathbf{Y_{ij}}=\mu + G_i + H_j + s_k + GH_{ij} + GS_{ik} + e_{ijkl}$

Where:

Y_{ij}= the observation of $ijkl^{th}$ bird.

μ = overall mean.

G_i = effect of i^{th} generation (I = 0, 1, 2)

H_j= effect of j^{th} hatch (j = 1, 2)

s_k= effect of k^{th} sex (k = male and female).

GH_{ij}= Interaction between i^{th} generation and j^{th} hatch

GS_{ik}= Interaction between i^{th} generation and k^{th} sex

e_{ijkl}= random error.

Significant differences between means were ranked by using Duncan's Multiple Range Test (Duncan,1955).

CHAPTER FOUR

4.0 RESULTS

4.1 Sexual Maturity Characteristics of Japanese Quails

4.1.1 Sexual maturity characteristics in females

The least square means for sexual maturity in female Japanese quail are shown in Table 4.1. The sexual maturity characteristics were significantly ($P< 0.05$) influenced by generations of selection. Age and body weight at sexual maturity, weight of first, egg weight, follicle size, oviduct weight, ovary weight, pectoral major weight and abdominal fat weight improved with increasing generations of selection. Age at sexual maturity was earliest in G_1 ($P< 0.05$) and similar ($P0.05$) between G_0 and G_2.

4.1.2 Sexual Maturity Characteristics in males

Table 4.2. Shows the least square means of sexual maturity characteristics of male Japanese quail by generations. The sexual maturity characteristics of the male Japanese quail differed significantly ($P< 0.05$), by generations. Body weight at day 35, age at sexual maturity in male, body weight at matirity, testicular weight and pectoral major improved. Abdominal fat weight also increased but was similar for G_1 and G_2 ($P< 0.05$).

Table 4.1: Least square means for sexual maturity characteristics of females Japanese quail by generations (n =50)

Traits	G_0	G_1	G_2	LoS
	M±SE	M±SE	M±SE	
Body Weight at 35(d)	150.7±1.43^{c}	160.0±1.60^{b}	161.1±1.26^{a}	*
Age at Sexual Maturity	42.3±0.95^{a}	40.9±0.97^{b}	42.6±0.64^{a}	*
Body Weight(g) at sexual maturity	162.4±1.39^{c}	172.8±1.25^{b}	173.1±1.53^{a}	**
Egg Weight of first egg(g)	8.4±0.22^{c}	9.9±0.22^{b}	10.1±0.93^{a}	*
Follicle Number (n)	20.7±0.67^{a}	15.5±0.53^{b}	14.8±0.47^{c}	*
Follicle weight (g)	2.9±0.19^{c}	7.4±0.25^{b}	8.7±0.26^{a}	**
Oviduct Weight(g)	5.7±0.23^{c}	7.8±0.31^{b}	8.4±0.40^{a}	*
Ovary Weight(g)	5.2±0.23^{c}	6.9±0.17^{b}	7.4±0.35^{a}	*
Pectoral Major Weight(g)	63.2±1.54^{b}	61.1±1.61^{c}	66.9±1.36^{a}	*
Abdominal fat Weight(g)	2.7±0.10^{c}	3.4±0.04^{b}	3.5±0.04^{a}	*

'Means within each generations raw with different superscripts differ*= ($P< 0.05$),**=($P < 0.01$); NS = not significant, LoS= Level of significance,G_0=Base population, G_1=Generation one; G_2= Generation two

Table 4.2: Least square means for sexual maturity characteristics of males Japanese quail by Generations

Traits	G_0	G_1	G_2	LoS
	M±SE	M±SE	M±SE	
Body Weight at 35(d)	136.6 ± 1.32^{c}	153.5 ± 1.47^{b}	155.5 ± 0.57^{a}	**
Age at sexual maturity male	40.7 ± 0.71^{a}	37.9 ± 0.45^{c}	39.6 ± 0.69^{b}	*
Body weight at sexual maturity (g)	156.7 ± 1.54^{b}	169.4 ± 1.10^{a}	169.0 ± 0.60^{a}	**
Testicular Weight(g)	3.1 ± 0.18^{c}	5.3 ± 0.84^{b}	5.4 ± 0.14^{a}	**
Pectoral Major Weight(g)	52.0 ± 0.92^{c}	59.2 ± 1.71^{b}	62.8 ± 1.49^{a}	*
Abdominal fat Weight (g)	2.8 ± 0.11^{b}	3.3 ± 0.06^{a}	3.3 ± 0.06^{a}	*

Means within each generations row with different superscripts differ*= ($P< 0.05$),**=($P< 0.01$); LoS= Level of significance, G0 = Base population; G1= Generation one; G2 = Generation two.

4.2 Carcass Traits, Body length and Body Parts of Japanese Quail

4.2.1 Carcass traits of Japanese quail by generations and sex

The least square means of carcass traits of Japanese quail by generations and sex is shown in Table 4.3. The carcass traits in male and female generations differed significantly ($P< 0.05$). Body weight at day 35, 42, 49 and 56 in males were less than in females. Also at day 56 carcass weight, breast weight, drumstick + thigh weight, % drumstick + thigh weight, back bone weight and % back bone weight were also less in males than in females. However, males had higher % carcass weight, abdominal fat weight, % abdominal fat weight and % breast weight ($P>0.05$).While there was increase in generations selected for other traits.

4.2.2 BW56 Body length and some parts of Japanese quail

Table 4.4. Shows the least square means for Body weight at day 56 Body length and some parts for the males and females and also generations G_0, G_1, G_2 .The result indicated that at day 56 males had higher ($P< 0.05$) keel bone length, breast length shank length and wing length while females had higher toe and feather length. Pelvic width, thigh length, abdominal fat and breast width were similar (($P< 0.05$) in both sexes. The result indicated that at day 56 there was an increase in body length, keel bone length, breast length, shank length, wing length and feather length for both males and females. Body length at day 49 and at day 56 body weight, keel bone length, pelvic width also length, abdominal fat length and breast width increased with generations.

Table 4.3: Least square means of carcass traits of Japanese quail by generation and sex

Traits		Sex			Generation			
		Males	Females		G_0	G_1	G_2	
	N	**M**±SE	**M**±SE	LoS	**M**±SE	**M**±SE	**M**±SE	LoS
Body Weight 35d (g)	56	145.0±1.73^{b}	147.8±1.65^{a}	**	134.3±1.67^{c}	147.2±1.54^{b}	157.8±2.28^{a}	*
Body Weight 42d (g)	56	164.0±1.83^{b}	176.5±1.80^{a}	*	148.5±1.73^{c}	176.5±1.78^{b}	185.9±3.18^{a}	*
Body Weight 49d (g)	56	181.2±1.82^{b}	203.6±1.92^{a}	*	178.8±1.34^{c}	191.1±2.10^{b}	207.2±2.17^{a}	*
Body Weight 56d (g)	56	207.3±2.37^{b}	235.8±2.02^{a}	*	202.0±2.76^{c}	218.5±2.56^{b}	244.1±2.67^{a}	*
DAY 56								
Carcass Weight(g)	56	185.9±1.41^{b}	207.6±1.92^{a}	*	182.41±2.32^{c}	195.9±2.10^{b}	211.8±2.32^{a}	*
% Carcass Weight	56	89.7±0.62^{a}	88.1±0.92^{b}	**	90.3±1.72^{a}	89.6±0.72^{b}	88.9±1.67^{c}	**
Abdominal Fat Weight(g)	56	7.2±0.15^{a}	6.9±0.08^{b}	*	7.0±0.08^{b}	6.7±0.12^{c}	7.3±0.13^{a}	**
%AbdominalFat Weight	56	3.9±0.09^{a}	3.3±0.08^{b}	**	3.9±0.05^{a}	3.4±0.42^{c}	3.5±0.52^{b}	**
Breast Weight (g)	56	70.4±0.36^{b}	77.8±0.23^{a}	*	60.8±0.42^{c}	75.5±0.56^{b}	85.9±0.46^{a}	*
%Breast Weight	56	37.7±0.12^{a}	37.2±0.28^{b}	**	33.4±0.44^{c}	38.5±0.21^{b}	40.6±0.38^{a}	**
Drumstick+ThighWeight(g)	56	44.2±0.24^{b}	57.5±0.25^{a}	*	35.0±0.53^{c}	53.7±0.35^{b}	63.9±0.58^{a}	*
% Drumstick+ Thigh Weight	56	23.6±0.21^{b}	27.3±0.18^{a}	*	19.2±0.39^{c}	27.2±0.32^{b}	30.0±0.22^{a}	**
BacK Bone Weight (g)	56	57.4±0.74^{b}	66.3±0.82^{a}	*	49.0±0.95^{c}	61.3±1.89^{b}	75.4±1.28^{a}	*
% BacK BoneWeight	56	30.7±1.42^{b}	31.7±0.62^{a}	**	28.8±1.28^{c}	31.3±1.32^{b}	35.5±1.62^{a}	*

Means within each row for the sexes and generations with different superscripts differ*= ($P< 0.05$),**=($P< 0.01$); LoS= Level of significance,G0 = Base population;G1= Generation one; G2 = Generation two.

Table 4.4: Least square means for some parts of Japanese quail of different generations and sex

Traits		Sex			Generation			
		Males	Females		G_0	G_1	G_2	
	N	**M**±SE	**M**±SE	LoS	**M**±SE	**M**±SE	**M**±SE	LoS
Body length35(cm)	56	14.1±0.37^{a}	14.0±0.67^{b}	**	13.7±0.53^{c}	14.1±0.32^{a}	14.2±0.81^{a}	*
Body length42(cm)	56	14.8±0.32^{b}	15.0±0.27^{a}	*	14.5±0.45^{c}	15.9±0.42^{a}	15.5±0.24^{a}	*
Body length49(cm)	56	14.6±0.34^{b}	14.9±0.26^{a}	*	14.2±0.42^{c}	14.8±0.31^{b}	15.2±0.22^{a}	*
Body length56(cm)	56	15.2±0.21^{b}	15.7±0.16^{a}	*	15.2±0.54^{b}	15.4±0.16^{b}	15.7±0.32^{a}	*
Body Weight 56(g)	56	207.3±2.76^{b}	235.8±2.3^{a}	*	202.1±2.94^{c}	218.5±2.12^{b}	244.1±2.52^{a}	**
DAY 56:								
Keel bone Length (cm)	56	9.3±0.09^{a}	9.2±0.08^{b}	*	9.0±0.41^{c}	9.2±0.21^{b}	9.5±0.14^{a}	*
Pelvic Width (cm)	56	3.2±0.08^{a}	3.2±0.07^{a}	Ns	2.8±0.28^{c}	3.2±0.82^{b}	3.5±0.08^{a}	*
Breast Length (cm)	56	13.2±0.29^{a}	12.2±0.28^{b}	**	12.6±0.18^{b}	12.6±0.31^{b}	12.9±0.23^{a}	*
Shank Length (cm)	56	3.2±0.14^{a}	3.1±0.30^{b}	*	2.9±0.08^{c}	3.2±0.07^{b}	3.4±0.08^{a}	*
Toe Length (cm)	56	3.4±0.02^{b}	3.5±0.03^{a}	**	3.2±0.07^{c}	3.5±0.05^{b}	3.6±0.62^{a}	*
Thigh Length (cm)	56	8.3±0.14^{a}	8.3±0.15^{a}	Ns	8.1±0.22^{c}	8.3±0.12^{b}	8.6±0.14^{a}	*
Wing Length (cm)	56	11.6±0.03^{a}	11.3±0.02^{b}	*	11.2±0.04^{b}	11.3±0.06^{b}	11.8±0.07^{a}	*
Abdominal Fat (cm)	56	0.6±0.02^{a}	0.6±0.01^{a}	Ns	0.4±0.23^{c}	0.6±0.02^{b}	0.7±0.08^{a}	*
Feather Length (cm)	56	10.7±0.22^{b}	11.0±0.12^{a}	*	10.6±0.42^{b}	11.0±0.53^{a}	11.2±0.01^{a}	*
Breast Wide (cm)	56	3.1±0.05^{a}	3.1±0.02^{a}	*	2.9±0.22^{c}	3.1±0.01^{b}	3.3±0.02^{a}	**

Means within each row for the sexes and generations columns with different superscripts differ*= ($P< 0.05$),**=($P < 0.01$); NS = not significant, LS= Level of significance, G_0 = Base population; G_1= Generation one; G_2 = Generation two.

4.3 Egg Characteristics of Japanese Quail.

4.3.1 Egg weight, yolk and albumen characteristics of Japanese Quail.

The least square mean for egg quality characteristics of Japanese quail in different generations and age are shown in Table 4.5 All the egg quality characteristics improved ($P< 0.05$) with generation except shell weight which was lowest ($P< 0.05$) in G_2 quail and shell thickness which was highest ($P< 0.05$) in G_2 and shell thickness was highest ($P< 0.05$) in G_0 Egg weight, egg length, egg width, yolk weight, yolk length and shell thickness improved as the birds advanced in age.However, both shell weight and thickness decreased with age.

There was increase in albumen weight and albumen width with increasing age. The three albumen characterisyics differed significantly ($P< 0.05$) across generation. Albumen weight decreased significantly($P< 0.05$) with generation while albumen width increased significantly ($P< 0.05$). However value albumen length was highest ($P< 0.05$) in generation of base population and similar in G_1 and G_2.

Table 4.5: Least square means for egg weight and yolk characteristics of Japanese quail at different generations and age

Traits		Generations			LoS	Age(g)				LoS
		G_0	G_1	G_2		D_{35}	D_{42}	D_{49}	D_{56}	
Egg weight(g)	56	8.3±1.21^{c}	9.5±1.22^{b}	10.2±1.23^{a}	*	7.5±0.61^{d}	8.7±0.82^{c}	10.1±1.32^{b}	10.9±0.17^{a}	*
Egg length(cm)	56	2.9±0.11^{c}	3.4±0.18^{b}	3.8±0.22^{a}	*	2.8±0.14^{d}	3.1±0.08^{c}	3.6±0.11^{b}	3.9±0.13^{a}	*
Egg width(cm)	56	2.4±0.18^{c}	2.6±0.18^{b}	2.9±0.24^{a}	*	2.3±0.21^{c}	2.5±0.31^{b}	2.3±0.09^{c}	3.1±0.15^{a}	**
Yolk weight(g)	56	3.7±0.25^{c}	4.1±0.26^{b}	4.4±0.23^{a}	*	3.1±0.32^{d}	3.8±0.24^{c}	4.5±0.21^{b}	4.8±0.31^{a}	*
Yolklength (cm)	56	1.3±0.12^{b}	1.6±0.21^{a}	1.6±0.13^{a}	*	1.3±0.12^{d}	1.4±0.21^{c}	1.6±0.32^{b}	1.7±0.11^{a}	**
Yolk width (cm)	56	2.2±0.13^{b}	2.3±0.13^{a}	2.3±0.14^{a}	*	2.2±0.13^{b}	2.3±0.22^{a}	2.2±0.14^{b}	2.3±0.13^{a}	*
Albumen weight	56	3.2±0.12^{c}	3.3±0.12^{b}	3.6±0.13^{a}	**	3.0±0.11^{d}	3.2±0.34^{c}	3.4±0.14^{b}	3.5±0.13^{a}	*
Albumen length	56	1.0±0.22^{a}	0.3±0.15^{b}	0.3±0.09^{b}	*	0.3±0.02^{b}	0.3±0.12^{b}	0.3±0.11^{b}	1.2±0.17^{a}	*
Albumen width	56	3.0±0.04^{c}	3.1±0.13^{b}	3.3±0.22^{a}	*	2.5±0.04^{d}	2.9±0.23^{c}	3.5±0.22^{a}	3.4±0.13^{b}	*
Shell weight(g)	56	0.4±0.02^{a}	0.4±0.02^{a}	0.3±0.09^{b}	*	0.4±0.51^{a}	0.4±0.11^{a}	0.3±0.02^{b}	0.3±0.05^{b}	*
Shell thickness	56	0.3±0.04^{a}	0.2±0.02^{b}	0.2±0.04^{b}	*	0.4±0.04^{a}	0.3±0.02^{a}	0.2±0.04^{b}	0.1±0.02^{c}	**

Means for each trait within generations and ages with different superscripts differ*= ($P< 0.05$),**=($P< 0.01$); LoS= Level of significance,G_0=Generation of unselected parent; G_1=Generation one, Generation two N=number of birds observed.

4.3.2 Performance Characteristics of Quial Hens

The least square means for egg production, egg weight and body weight of Japanese quail hens at different ages are shown in Table 4.6. All the traits were significant ($P< 0.05$) affected by age. The egg production and egg weight in Japanese quail by age differed significantly ($P< 0.05$) . As birds advanced in age, there was significanly ($P< 0.05$) increase in the following traits: with age from day 35 to 56 in all the generations except Base population generation (G_0) in which the egg production increases in day 49 and then decreases thereafter.Also the females body weight in both base population generation (G_0) , selected generation one (G_1) and selected generation two (G_2) increase with increase in the ages of the birds from day 35 to 56.

4.4 Carcass Traits as Influenced by Sex, Age and Generations in Japanese Quail.

4.4.1 Carcass parts traits

Table 4.7 shows least square means for carcass traits in generations of Japanese quail as influenced by sex and age. Generally, Sex, Generation of selection and Age of the birds had significant ($P< 0.05 - 0.01$) effect on the carcass characteristics.The females had superior carcass characteristics than the males.The carcass characteristics increaseed with generations of selection with G_2 having higher characteristics than G_0 and G_1. The carcass characteristics of the bird increase with increase in the ages of birds except the internal organs; liver, heart and lungs weight.

Table 4.6: Least square means for egg production and weight traits in Japanese quail by age

Traits	Age (d)				LoS
	D_{35}	D_{42}	D_{49}	D_{56}	
Average weekly egg production G_0	165±7.19^{d}	952±1.92^{c}	1382±3.23^{a}	1221±3.67^{b}	*
Average weekly egg production G_1	266±2.29^{d}	915±48.88^{c}	1318±3.95^{a}	1197±4.06^{b}	**
Average weekly egg production G_2	242±6.15^{d}	870±4.86^{c}	1219±27.70^{a}	1162±9.86^{b}	*
Body Weight female G_0	135.9±1.59^{d}	160.1±1.65^{c}	184.6±1.79^{b}	212.9±2.37^{a}	*
Body Weight female G_1	148.5±1.63^{d}	180.6±1.73^{c}	202.5±2.31^{b}	223.8±2.84^{a}	*
Body Weight female G_2	159.1±2.34^{d}	188.9±3.32^{c}	231.6±2.94^{b}	262.9±3.52^{a}	*
Egg Weight G_0	6.7±0.81^{d}	7.6±1.04^{c}	9.2±0.97^{b}	9.6 ±0.80^{a}	*
Egg Weight G_1	7.8±0.67^{d}	8.8±0.97^{c}	10.2±0.97^{b}	11.3±1.34^{a}	*
Egg Weight G_2	8.4±1.02^{d}	9.6±0.91^{c}	10.0±0.96^{b}	11.9±1.17^{a}	*

means of each traits within each generation with different superscripts differ*= ($P< 0.05$), **=($P< 0.01$); LoS = least of significant,, G_0= Base population, G_1= generation of selected 1, G_2= generation of selected 2.

Table. 4.7: Least square means for carcass traits in generations of Japanese quail as influenced by sex and age

Characteristics		Sex		LoS	Generations			LoS	Age(d)				LoS
		Males	Females		G_0	G_1	G_2		D_{35}	D_{42}	D_{49}	D_{56}	
Livebody weight(g)	56	174.6±3.12^{b}	188.5±2.45^{a}	*	167.0±2.95^{c}	182.5±2.40^{b}	195.0±3.84^{a}	*	146.4±3.72^{d}	171.7±3.42^{c}	191.3±2.48^{a}	181.5±4.12^{b}	**
Carcass weight(g)	56	155.8±2.56^{b}	169.1±2.82^{a}	*	152.8±3.21^{c}	164.9±4.24^{b}	169.6±3.86^{a}	**	134.3±2.45^{d}	156.3±2.88^{c}	171.7±2.48^{b}	187.5±4.24^{a}	*
Breast weight(g)	56	58.2±0.74^{b}	62.2±0.82^{a}	**	48.8±1.24^{c}	61.5±1.43^{b}	70.4±1.28^{a}	*	44.1±1.21^{d}	56.7±1.02^{c}	66.1±2.36^{b}	74.0±1.38^{a}	*
Drumstick+Thigh weight(g)	56	37.9±0.28^{b}	45.1±0.24^{a}	*	29.4±1.41^{c}	43.4±1.32^{b}	51.7±1.12^{a}	*	29.5±0.24^{d}	39.8±1.41^{c}	45.8±1.02^{b}	50.9±1.38^{a}	*
%Carcass weight	56	105.4±0.23^{b}	108.8±0.03^{a}	*	94.7±1.24^{c}	100.1±1.36^{b}	126.5±1.23^{a}	*	91.5±0.06^{d}	99.5±1.42^{c}	108.8±1.23^{b}	128.7±1.22^{a}	*
% Breast weight	56	36.9±1.32^{b}	36.5±1.42^{a}	*	31.5±0.12^{c}	37.7±1.02^{b}	40.9±0.24^{a}	*	32.6±0.12^{d}	35.5±1.02^{c}	38.4±0.24^{b}	40.4±1.02^{a}	*
Neck weight(g)	56	6.4±1.42^{b}	6.6±1.23^{a}	**	4.4±0.09^{c}	7.0±0.08^{b}	8.1±0.32^{a}	*	6.0±0.10^{d}	6.3±0.15^{c}	7.0±0.13^{b}	6.7±0.42^{a}	**
Back weight(g)	56	44.8±1.12^{b}	53.4±1.24^{a}	*	39.3±1.28^{c}	49.7±1.49^{b}	58.2±1.27^{a}	**	36.7±1.04^{d}	45.3±1.34^{c}	52.6±1.26^{b}	61.8±1.27^{a}	*
Intestine weight(g)	56	7.4±1.13^{b}	9.3±1.12^{a}	*	5.5±0.23^{c}	9.9±0.14^{a}	9.8±0.36b	**	6.2±1.12^{d}	7.0±0.81^{c}	8.1±1.22^{b}	8.4±1.32^{a}	**
Liver weight(g)	56	3.7±0.08^{b}	5.5±0.02^{a}	*	2.6±0.23^{b}	5.6±0.26^{a}	5.6±0.24a	*	3.7±0.14^{d}	3.8±0.24^{c}	4.9±0.16^{a}	4.6±1.34^{b}	**
Heart weight(g)	56	3.5±0.11^{b}	4.3±0.01^{a}	*	1.2±0.02^{c}	5.7±0.32^{a}	4.9±0.06b	*	4.0±0.12^{c}	4.4±0.32^{a}	4.2±0.05^{b}	3.9±0.02^{d}	**
Lung weight(g)	56	2.4±0.04^{b}	2.5±0.02^{a}	**	1.1±0.10^{c}	2.5±0.02^{b}	4.1±0.18a	*	2.0±0.05^{c}	1.6±0.18^{d}	2.6±0.03^{a}	2.5±1.23^{b}	**

Means within each generations columns with different superscripts differ*= ($P< 0.05$),**=($P< 0.01$);,LoS= Level of significance,G_0=Generation of unselected parents,G_1=Generation one., G_2=Generation two,

4.4.2 Carcass weight and some internal organs and inedible traits

The least square means for carcass weight and some internal organs and inedible traits of Japanese quail as influenced by sex, generation and age are shown in Table 4.8. The results shows generally that sex, generation and age of birds had significant ($P< 0.05 - 0.01$) effect on carcass weight, internal and inedible traits but the females has higher carcass weight, internal and inedible weight than males except kidney weight and testicular weight.The carcass, internal and inedible weight with selection in generations and also with age of the birds.

4.4.3 Carcass and live body dimensions

Table 4.9. shows the least square means for carcass and live body dimensions of Japanese quail as influenced by sex, generation and age. Live body dimensions of Japanese quail were influenced by sex, generation and age significantly ($P< 0.05 - 0.01$) except keel bone length, abdominal fat width in sex of Japanese qauil. Female quails performed better than males in carcass weight, live body weight and feather length. Equally, increasing generation of selection and advance in the ages of these birds improved performance in these characteristics.

Table 4.8: Least square means for carcass weight and some internal organs and inedible traits of Japanese quail as influenced by sex, generation and age

Characteristics		Sex		LoS	Generations			LoS	Age(d)				LoS
		Males	Females		G_0	G_1	G_2		D_{35}	D_{42}	D_{49}	D_{56}	
Carcass weight(g)	56	155.7±2.83^{b}	169.1±3.42^{a}	*	152.7±3.86^{c}	164.9±3.24^{b}	169.6±2.13^{a}	*	134.3±3.24^{d}	156.2±2.89^{c}	171.7±1.24^{b}	187.4±3.24^{a}	*
Gizzard weight(g)	56	4.7±1.23^{a}	4.4±3.03^{b}	*	3.2±1.20^{c}	4.9±0.81^{b}	5.6±0.73^{a}	*	4.3±1.02^{d}	4.5±0.89^{c}	4.6±0.81^{b}	4.8±0.52^{a}	*
Kidney weight(g)	56	0.8±0.02^{a}	0.8±0.16^{a}	*	0.5±1.02^{c}	1.1±0.42^{a}	0.8±0.89^{b}	**	0.7±0.21^{b}	0.6±0.27^{c}	0.7±0.67^{b}	1.2±0.92^{a}	*
Testicularweight (g)	56	2.4±0.02	Nil	Ns	2.4±0.82^{c}	4.9±0.42^{b}	5.1±0.29^{a}	**	1.6±0.12^{d}	2.0±0.45^{c}	2.2±0.18^{a}	2.1±0.16^{b}	*
Head weight(g)	56	6.3±2.88^{b}	6.6±3.26^{a}	*	4.6±3.24^{c}	7.0±2.42^{b}	7.7±2.83^{a}	*	5.9±1.20^{d}	6.2±0.72^{c}	6.5±0.02^{b}	7.2±1.34^{a}	**
Neck weight(g)	56	6.2±2.48^{b}	6.6±2.84^{a}	*	4.4±0.83^{c}	6.9±0.72^{b}	8.0±0.68^{a}	*	5.9±0.12^{d}	6.2±0.38^{c}	7.0±0.62^{a}	6.6±0.14^{b}	*
Leg weight(g)	56	3.4±4.21^{b}	4.6±2.07^{a}	*	2.2±0.06^{c}	4.5±0.82^{b}	5.3±0.05^{a}	*	3.3±0.02^{d}	3.6±0.01^{c}	3.9±0.73^{b}	5.3±1.20^{a}	s
Wing weight(g)	56	8.1±2.87^{b}	8.8±3.14^{a}	*	6.7±2.45^{c}	8.9±0.50^{b}	9.7±1.28^{a}	*	8.6±0.14^{c}	8.7±0.34^{a}	7.8±0.79^{b}	8.8±0.73^{a}	*
Abdominal weight(g)	56	5.4±2.46^{b}	5.6±2.24^{a}	*	5.0±2.84^{b}	5.2±0.02^{b}	6.4±2.01^{a}	*	3.7±0.08^{d}	5.0±0.04^{c}	6.3±0.53^{b}	7.0±1.09^{a}	*
Feather weight(g)	56	16.5±4.32^{b}	17.9±3.86^{a}	*	15.0±3.76^{c}	18.6±0.78^{a}	17.9±0.78^{b}	*	11.9±0.14^{d}	14.8±0.83^{c}	19.7±0.72^{b}	22.4±1.02^{a}	*

Means within sex generations and age with different superscripts differ*= ($P< 0.05$),**=($P< 0.01$); LoS= Level of significance, G_0=Base population; G_1=Generation one; G_2=Generation two.

Table 4. 9: Least square means for carcass and live body dimensions of Japanese quail as influenced by sex, generation and age

Characteristics	N	Sex		LoS	Generations			LoS	Age(g)				LoS
		Males	Females		G_0	G_1	G_2		D_{35}	D_{42}	D_{49}	D_{56}	
Livebody weight(g)	56	174.6±3.07^{b}	188.5±3.24^{a}	**	167.1±2.27^{c}	182.5±3.21^{b}	195.0±1.72^{a}	*	146.4±2.71^{d}	171.7±1.28^{c}	191.3±1.71^{b}	216.8±2.82^{a}	*
Carcass weight(g)	56	155.7±2.45^{b}	169.1±2.83^{a}	**	152.7±2.45^{c}	164.9±3.75^{b}	169.6±3.62^{a}	**	134.3±1.21^{d}	156.2±0.46^{c}	171.7±2.17^{b}	187.5±1.24^{a}	*
Body length(cm)	56	14.6±0.25^{a}	14.9±0.34^{a}	*	14.3±0.15^{c}	14.8±0.83^{b}	15.2±0.21^{a}	**	14.1±0.71^{c}	14.9±0.32^{b}	14.7±1.34^{b}	15.4±1.72^{a}	*
Keel bone length(cm)	56	7.8±0.22^{a}	7.8±0.23	Ns	7.5±0.67^{b}	7.8±0.71^{b}	8.1±0.12^{a}	*	5.9±1.62^{c}	8.0±0.34^{b}	8.1±1.72^{b}	9.2±0.89^{a}	*
Pelvic width (cm)	56	2.4±0.08^{b}	2.6±0.06^{a}	**	2.4±0.12^{b}	2.5±0.32^{a}	2.6±0.26^{a}	*	0.3±2.34^{b}	3.2±1.78^{a}	3.2±0.24^{a}	3.3±2.17^{a}	*
Shank length (cm)	56	3.0±0.31^{a}	3.3±0.15^{a}	*	2.8±0.12^{b}	3.0±0.14^{a}	3.1±0.22^{a}	*	2.3±0.24^{b}	3.2±0.32^{a}	3.6±0.63^{a}	4.0±0.81^{a}	**
Thigh length (cm)	56	7.5±0.32^{a}	7.6±0.25^{a}	*	7.2±0.52^{b}	7.6±0.42^{a}	7.9±0.28^{a}	*	6.5±0.67^{c}	7.4±1.24^{b}	7.6±1.08^{b}	8.2±0.79^{a}	**
Wing length (cm)	56	10.4±0.89^{b}	10.5±1.45^{a}	**	10.2±0.27^{b}	10.5±0.89^{a}	10.6±0.73^{a}	*	9.6±0.62^{c}	10.5±2.12^{b}	10.5±1.73	11.4±1.34^{a}	*
Abdominal fat width(cm)	56	0.4±0.01^{a}	0.4±0.02^{a}	Ns	0.2±0.08^{c}	0.4±0.11^{b}	0.6±0.09^{a}	*	0.2±0.71^{c}	0.4±0.81^{b}	0.4±0.24^{b}	0.6±0.41^{a}	*
Feather length(cm)	56	9.3±0.18^{b}	12.3±0.41^{a}	*	8.9±1.12^{c}	9.3±0.78^{b}	9.8±1.23^{a}	*	7.0±1.34^{d}	9.0±0.78^{c}	10.1±1.22^{b}	11.1±2.15^{a}	*

Means within sex generations and age with different superscripts differ*= ($P< 0.05$),**=($P< 0.01$); NS = Not significant,LoS= Level of significance, G_0=Base population; G_1=Generation one; G_2=Generation two.

4.5 Breast meat quality of Japanese quail by age and sex

Table 4.10 shows the least square means (LSM) of breast meat quality of Japanese quail as affected by age and sex. Sex had no significant (P>0.05) effect on the breast meat quality except keel bone length and abdminal fat. The cooking loss and Chroma of the males breast meat was higher than that of the females, while the females breast meat had higher water holding capacity (Pectoralis major) and lightness.

Slaughter age had significant effect (P<0.01-0.01) on the breast meat quality. The pH_{20mm}, % drip loss, water holding capacity (pectoralis major) and lightness of the breast meat decreased as the birds, were getting older, while cooking loss (breast muscle), redness, Chroma and Hue increased significantly with slaughter age.

4.6 Response to Genetic Improvement in Traits of Japanese Quail

4.6.1 Response to Rate of genetic improvement for body weight and shank length inJapanese Quail

The rate of genetic improvement for body weight and shank length of Japanese quail by sex at different ages are shown in Table 4.11. Generally, there was improvement in body weight across generation in all the ages (day 35 to 56). The rates of improvement in body weight across generation one and two were 3.24g (0.05%) in day 35 day, -1.85 (0.87%) in day 42 day, 4.21g (49day), -19.4g (56day), for males and -4.72g (35day), -5.92g (42day), 3.36g (49day) -14.95g (56day) for females. There was greater rates of improvement in shank length of males across generations.

Table 4.10: Least square means of breast meat quality of Japanese quail as influeced by age and sex

Characteristics	N	Sex		LoS	Slaughter age (d)				LoS
		Males	Females		D_{35}	D_{42}	D_{49}	D_{56}	
pH_{20mins}	10	6.1±0.22[a]	6.3±0.15[a]	*	6.5±0.18[a]	6.5±0.20[a]	6.05±0.19[b]	6.0±0.12[b]	*
$pH_{24hours}$	10	5.9±0.11[a]	5.8±0.01[a]	*	5.9±0.03[a]	5.8±0.02[a]	5.8±0.01[b]	5.3±0.05[b]	*
% Drip loss	10	0.8±0.01[a]	0.8±0.04[a]	Ns	4.0±0.02[d]	0.8±0.02[a]	0.7±0.03[b]	0.6±0.0.05[c]	**
pectoralis major,water holding capacity	10	17.7±0.62[b]	20.3±0.41[a]	*	17.9±0.41[c]	18.7±0.43[b]	19.7±0.45[a]	19.8±0.0.46[a]	*
Pectoralis major, water absorbing capacity	10	23.4±0.62[a]	23.4±1.75[a]	*	27.2±1.75[a]	23.7±1.91[b]	22.8±1.11[b]	19.9±1.89[c]	*
Cooking loss, breast muscle	10	31.1±2.47[a]	27.3±0.85[b]	*	25.4±0.85[d]	26.6±1.56[b]	30.1±1.56[c]	34.9±0.78[a]	*
Lightness(^{L})	10	42.9±0.52[c]	44.4±0.83[a]	**	44.8±0.93[a]	43.7±0.85[b]	43.5±0.03[b]	42.7±0.56[d]	*
Redness(^{a})	10	10.8±0.41[a]	10.7±0.40[a]	*	10.1±0.41[a]	10.4±0.40[a]	11.0±0.48[b]	11.4±0.25[b]	*
Yellowness(^{b})	10	11.0±0.20[a]	11.4±0.32[a]	*	11.1±0.32[a]	11.3±0.36[a]	11.1±0.31[a]	11.3±0.61[a]	*
Chroma(C^{o})	10	15.2±0.46[a]	14.9±0.36[b]	*	14.4±0.17[d]	15.5±0.57[b]	15.5±0.42[c]	15.7±0.46[a]	*
Hue(h^{o})	10	0.7±0.17[a]	0.7±0.59[a]	Ns	0.6±0.06[c]	0.7±0.05[b]	0.8±0.02[a]	0.8±0.03[a]	*

Means for each character within sex generations and age with different superscripts differ*= ($P< 0.05$),**=($P< 0.01$); G_0= Base population; G_1=Generation one, G_2=Generation two, p^H20min = p^H value after 20min postmortem; p^H24hr = p^H value after 24hr postmortem

Table 4.11: Response to genetic improvement for body weight and shank length in generations of Japanse quail.

Traits	Sex	Generations			Response to selection			
		G_0	G_1	G_2	ΔGR_1	ΔGR_2	$\%\Delta GR_1$	$\%\Delta GR_2$
Body Weight 35d (g)	Males	132.75	145.79	159.07	13.04	13.28	10.00	9.10
	Females	135.93	148.54	156.43	12.61	7.89	9.28	5.31
	Overall	134.34	147.17	157.75	12.83	10.58	9.55	7.88
Body Weight 42 d (g)	Males	160.11	172.39	182.82	12.28	10.43	7.66	6.05
	Females	166.29	180.57	188.93	14.37	8.36	8.64	4.63
	Overall	163.20	176.48	185.88	13.28	9.40	8.13	5.33
Body Weight 49 d (g)	Males	173.11	179.75	182.18	6.64	5.43	7.84	3.02
	Females	184.57	202.50	223.79	17.93	21.29	9.71	10.51
	Overall	178.84	191.13	202.99	12.29	11.86	6.87	6.21
Body Weight 56 d (g)	Males	191.29	205.39	238.89	14.10	33.50	7.37	16.31
	Females	212.89	231.57	225.32	18.68	-6.25	8.77	2.70
	Overall	202.09	218.48	232.11	16.39	13.63	8.11	6.24
Shank Length 35d (cm)	Males	3.50	3.80	4.30	0.30	0.50	8.57	13.16
	Females	3.50	3.90	4.00	0.40	0.10	11.43	2.56
	Overall	3.50	3.85	4.15	0.35	0.30	10.00	7.80
Shank Length $_{42d\ (cm)}$	Males	3.10	3.10	3.40	0.10	0.20	3.23	6.25
	Females	2.90	3.20	3.50	0.30	0.30	10.34	9.37
	Overall	3.00	3.15	3.45	0.15	0.25	5.00	7.94
Shank Length 49d (cm)	Males	2.90	3.30	3.50	0.40	0.20	13.79	6.06
	Females	2.90	3.20	3.40	0.30	0.20	6.90	6.06
	0verall	2.90	3.25	3.45	0.35	0.20	1.21	6.15
Shank Length 56 (cm)	Males	3.00	3.20	3.40	0.20	0.20	6.67	6.25
	Females	2.90	3.10	3.40	0.20	0.30	6.90	9.68
	0verall	2.95	3.14	3.40	0.19	0.26	6.44	8.28

G_0= Base population; G_1=Generation one, G_2= Generation two,. $\Delta GR_=$ reponse to change in growth rate in generations; % ΔGR= percent reponse to change in growth rate in generations

one and two were 19.4g, respectively, while the rate of improvement in shank length of the females was -0.30g, 0.01g, -0.10g and 0.20g for age 35, 42, 49 and 56day, respectively, the faster rate was at day 56

4.6.2. The rate of improvement for growth rate in body weight and shank length in Japanese quail

Table 4.12 shows the rate of genetic improvement for growth rate in body weight and shank length in generation of Japanese quails. There was improvement in growth rate for body weight and shank length with selection. However, the rate of improvement differs with sex. The rates of improvement in growth rate for body weight in males at ages 35-42, 42-49, 49-56day were 1.39g (5.30%), 8.92g (4.45%) and 0.40g (-2.97%), respectively, while for the fesmales the rate of genetic improvement was 2.08g (-4.94%), 9.26g (3.89%) and 9.28g (0.81%) for ages 35.42, 42-49 and 49.56 day respectively.

The genetic improvement in the growth rate of the shank length in males were

-0.01g (-2.50%), 0.03g (-9.08%) and -0.01g (2.00%) for age 35-42, 42-49 and 49-56day, respectively, while for the females the genetic improvement was 0.11g (24.00%) 0.01g (-3.01%) and -0.01g (-1.00%) for ages 35-42, 42-49, and 49-56 day, respectively.

4.6.3. Estimated genetic improvement in female sexual reproductive traits of females

Table 4.13 showed the realized genetic improvement in the reproductive traits of females quail at sexual maturity. The realized genetic improvement in selection for improvement in female reproductive traits at age 35day of age was low but positive. The realized genetic improvement ranged from 1.22g (1.12%) (Abdominal fat weight) to 6.72g (1.10%) (pectoralis major weight).

Table 4.12: Rate of genetic improvement for growth rate in body weight and shank length in generations of Japanese quail

Traits	Sex	Generations		Response to selection			
		G_1	G_2	ΔGR_1	ΔGR_2	$\%\Delta R_1$	$\%\Delta R_2$
Growth Rate bodyweight 35-42d (g)	Males	26.60	28.75	0.76	2.15	2.78	8.08
	Females	32.03	39.86	1.67	7.83	5.50	2.44
	Overall	29.32	34.31	1.22	4.99	1.59	1.70
Growth Rate bodyweight 42-49 d (g)	Males	17.36	30.64	4.46	13.28	3.20	7.65
	Females	21.93	34.86	3.67	12.93	2.01	5.90
	Overall	19.65	32.75	4.02	13.10	2.57	6.67
Growth Rate bodyweight 49-56 d (g)	Males	25.64	33.50	7.46	7.86	4.10	3.07
	Females	29.07	39.10	0.75	10.03	2.64	3.45
	Overall	27.36	36.30	4.11	8.94	1.77	3.27
Growth Rate Shank Length 35-42 d(cm)	Males	0.67	0.91	0.25	0.24	5.00	3.58
	Females	0.59	0.73	0.03	0.14	5.36	2.37
	Overall	0.63	0.82	0.14	0.19	2.86	3.02
Growth Rate Shank Length 42-49 d(cm)	Males	0.06	0.12	0.03	0.09	1.00	10.08
	Females	0.02	0.11	0.01	0.08	1.00	25.00
	Overall	0.04	0.12	0.02	0.06	1.00	20.00
Growth Rate Shank Length 49-56 d(cm)	Males	0.04	0.06	0.03	0.02	3.00	5.00
	Females	0.06	0.03	0.04	-0.03	2.00	1.00
	Overall	0.05	0.05	0.04	0.03	2.00	15.00

G_0= Base population; G_1=Generation one, G_2=Generation two,. $\Delta \mathbf{G_R}$= response to selection in growth rate. $_{\%}\Delta \mathbf{G_{R=}}$ reponse to change in growth rate in generations. I= selection differential.

Table 4.13: Response to genetic improvement in female reproductive traits at sexual maturity

Traits	P_s	Po	P_1	I	ΔGg	% I	%ΔGg
Bodyweight at 35(d)	150.68	160.00	161.08	1.08	10.40	0.01	0.65
Age at sexual maturity (d)	41.28	42.62	42.60	-0.02	1.32	0.00	0.31
Body weight(g)	162.44	172.76	173.08	0.32	10.64	0.00	0.04
Egg Weight(g)	8.36	9.92	10.12	0.20	1.76	0.02	1.77
Follicle number (n)	20.72	15.52	14.80	0.72	-5.92	0.35	3.81
Follicle size (cm)	2.94	7.36	8.68	1.32	5.74	4.45	7.80
Oviduct Weight(g)	5.68	7.80	8.40	0.60	2.72	1.06	3.49
Ovary Weight(g)	5.24	6.92	7.36	0.44	2.12	0.84	3.06
Pectoralis Major Weight (g)	60.20	61.08	66.92	5.84	6.72	0.97	1.10
Abdominal fat Weight (g)	2.68	3.40	3.70	0.30	1.02	1.12	3.00

ΔGg= response to selection; I= selection differentail % I= percent selection differencial; % ΔGg= percent response to selection; P_s=mean body weight of selection; P_0= mean body weight of population;

4.6.4 Estimated correlated correlated improvement in male sexual reproductive traits

The estimated genetic improvement in body weight and reproductive traits in males at sexual maturity is shown in Table 4.14. Selection for improvement in male sexual reproductive traits age 35 of age day showed positive response. The realized improvements were 17.8g (1.10%) for body weight at age 35, and 2.35g (4.45%) for testis weight, 10.88g (0.18%) for pectoralis major weight and 0.40g (1.49%) for abdominal fat weight. However age at sexual maturity was delayed by 1.72 days (0.28%).

4.6.5 Correlated improvement in some reproductive and egg traits in Japanese quail.

The rate of genetic improvement in some reproductive and egg traits is shown in Table 4.15. Improvement in egg number showed negative response in both the first (-123) and second (- 283) generation. Also, selection for genetic improvement in age at sexual maturity was better in both males and female (was negative) in the first generation but was delayed in the second generation. Birth weight (combined sex) had low but positive (0.90g) response (11.39%) to selection. The selection for improvement in the percentage fertility and hatchability were negatively affected by body weight selection. Percentage death in shell, percentage dead in egg and percentage infertility..

Table 4.14: Response to genetic improvement in Male reproductive traits at sexual Maturity

Traits	P_0	Ps	P_1	I	ΔG	% I	% ΔG
Body weight 35d(g)	146.64	159.52	164.20	4.68	17.56	0.31	1.10
Age at sexual maturity(d)	40.72	37.92	39.64	1.72	-1.08	0.42	0.28
Body weight (g)	162.72	169.36	179.04	9.68	16.32	0.59	0.96
Testis Weight (g)	3.05	5.28	5.40	0.12	2.35	0.39	4.45
Pectoralis Major Weight (g)	56.96	59.2**1**	67.84	8.63	10.88	1.52	0.18
Abdominal fat Weight (g)	2.83	3.29	3.32	0.03	0.49	0.12	1.49

ΔGg= response to selection; I= selection differentail % I= percent selection differencial; % ΔGg= percent response to selection; P_S=mean body weight of selection; P_0=mean body weight of population;

Table 4.15: Correlated improvement in some reproductive and egg traits in Japanese quail.

Traits	Sex	Generations			Rate of response			
		G_0	G_1	G_2	ΔGR_1	ΔGR_2	$\%\Delta GR_1$	$\%\Delta GR_2$
Egg Number	-	3818	3695	3492	-123	-203	0.32	0.55
Age Sexual Maturity male(d)	Males	40.72	37.92	39.64	-28	1.72	6.88	0.43
Age Sexual Maturity female (d)	Females	42.28	40.92	42.60	-1.36	1.68	0.32	1.14
Birth $_{Weight}$ (g)	Combined sex	-	7.90	8.80	-	0.90	-	-
% Fertility	-	91.36	86.33	-	-5.03	-	0.55	-
% Hatchability	-	76.60	56.91	-	- 19.69	-	2.57	-
% Death in shell	-	8.09	13.54	-	5.45	-	6.74	-
% Dead in Egg	-	6.67	15.88	-	9.21	-	1.38	-
% infertility	-	9.22	13.67	-	4.45	-	4.83	-

G_0= Base population; G_1=Generation one, G_2=Generation two; ΔGR= response to change in growth rate

4.6.6 Response to genetic Improvement in egg quality traits

The selection response for improvement in egg quality traits was low but positive (Table 4.16) .The realized genetic improvement ranged from -0.06g (1.43%) shell weight) to 1.56g (3.21%), response to genetic gain in egg weight.

4.6.7 Genetic improvement of egg production at different ages in Japanese quail

The estimated genetic response in egg production of Japanese quail at different ages is shown in Table 4.17. The realized genetic improvement with age from day 35 to 49 and then decreased thereafter. The realized genetic improvement was 77g (3.40%), -82g (0.90%), -163g (1.24%) and -59g (0.49%) at age 35, 42, 49 and 56 day, respectively.

4. 6.8 Response to genetic improvement of body weight at different ages of growth

The genetic improvement in body weight at different ages of Japanese quail by sex is shown in Table 4.18. There was a positive response in selection for body weight from age 35 to 56 day. However, the rate of genetic improvement was higher in males than females at 35 and 42 days of age, but beyond the 42 days of age, the females showed superiority over the males.

Table 4.16: Response to genetic improvement in egg quality traits for each generation

Traits	P_s	Po	P_1	I	ΔG	% I	% ΔG
Egg weight(g)	9.61	11.86	13.42	1.56	3.81	1.62	3.21
Egg Length(cm)	3.06	4.38	5.05	0.67	1.99	2.19	4.45
Egg width(cm)	3.06	4.38	5.19	0.81	2.13	2.65	4.86
Yolk weight(g)	4.74	4.92	5.03	0.11	0.29	0.23	0.59
Yolk Length(cm)	1.33	2.21	2.23	0.02	0.90	0.15	0.41
Yolk width(cm)	2.26	2.33	2.47	0.14	0.21	0.62	0.90
Albumen weight(g)	3.19	3.37	3.97	0.60	0.78	1.88	2.31
Albumen Length(cm)	3.05	3.26	3.28	-0.02	0.23	0.07	0.68
Albumen width(cm)	3.13	4.41	4.44	0.03	1.31	0.10	2.97
Shell weight(g)	0.32	0.35	0.37	0.02	0.05	0.63	1.43
Shell thickness(cm)	0.28	0.17	0.11	-0.06	-0.17	2.14	1.00

ΔGg= response to selection; I= selection differentail % I= percent selection differencial; % ΔGg= percent response to selection; P_S=mean body weight of selection; P_0=mean body weight of population

Table 4.17: Response to genetic improvement of egg Production atdifferent ages in Japanese quail

Egg Production	P_s	P_0	P_1	I	ΔGg	% I	% ΔGg
Egg 35	165	266	242	101	77	6.12	3.40
Egg 42	952	915	870	-82	-82	0.86	0.90
Egg 49	1382	1318	1219	-64	-163	0.46	1.24
Egg 56	1221	1197	1162	-24	-59	0.20	0.49

ΔGg= response to selection; I= selection differentail % I= percent selection differencial; % ΔGg= percent response to selection; P_S=mean body weight of selection; P_0=mean body weight of population

Table 4.18: Response to genetic improvement of body weight at different ages of Japanese quail by sex

Traits	Sex	P_s	P_0	P_1	I	ΔGg	% I	% ΔGg
35d Body Weight	Males	132.75	145.79	159.07	13.28	26.32	1.00	1.81
	Females	135.93	148.54	156.43	7.89	20.50	0.58	1.38
	Overall	134.34	147.17	157.75	10.59	23.41	0.79	1.59
42d Body Weight	Males	160.11	172.39	182.82	10.43	22.71	0.65	1.32
	Females	166.29	180.57	188.93	8.36	22.64	0.50	1.25
	Overall	163.20	176.48	185.88	9.40	22.68	0.58	1.29
49d Body Weight	Males	173.11	179.75	182.18	2.43	9.07	0.14	0.50
	Females	184.57	202.50	223.79	21.29	39.22	0.15	1.94
	Overall	178.84	191.13	202.99	11.86	24.15	0.69	0.62
56d Body Weight	Males	191.29	208.84	208.89	0.05	17.60	0.01	0.84
	Females	212.89	231.57	225.32	-6.25	12.43	0.29	0.54
	Overall	202.09	220.21	217.11	-3.10	15.02	0.15	0.68

ΔGg= response to selection; I= selection differentail % I= percent selection differencial; % ΔGg= percent response to selection; P_S=mean body weight of selection; P_0=mean body weight of population

4.6.9 Changes genetic improvement of carcass weight for different ages of growth in Japanese quail

There was a positive response to selection for improvement in the carcass weight of Japanese quails from age 35 to 56 (Table 4.19). However, the realized genetic improvement in females was relatively higher 22.6g (1.67%), 22.3g (1.48%), 29.69g (1.63%) and 35.5g (1.71%), respectively for days 35, 42, 49 and 56) than that of the males; 20.00g (1.49%), 17.5g (1.49%), 17.5g (1.20%) and 23.49g (1.26%) for days 35, 42, 49 and 56, respectively.

4.6.10 Response to Mineral composition improvement in meat of Japanese quail

The selection response for improvement in the mineral composition of Japanese quail meat was low but positive (Table 4.20). The rate of improvement was similar in both males and females except Fe, Zn and P. The realized genetic improvement for males was -0.03g (0.20%) for Fe while that of the females was -0.40g (1.55%) Fe.

4.6.11 Response to chemical composition improvement for meat of Japanese quail

The estimated improvement in the chemical composition of Japanese quails meat by sex is shown in Table 4.21. The selection for improvement in the chemical composition of the quails meat ranges from – 8.04g (1.03%) to 8.87g (3.93%). The males showed higher improvement in the protein (CP) 8.87g (3.93%), Ash content in females was 1.25g (1.71%). While females showed superior improvement on NFE than males.

Table 4.19: Response to genetic improvement of carcass weight for different ages by sex in Japanese quail

Traits	Sex	P_s	P_0	P_1	I	Gg	% I	% Gg
35d CarcassWeight(g)	Males	22.0	134.0	142.0	20.0	20.0	0.66	1.49
	Females	124.0	135.0	146.6	22.6	22.6	0.94	1.67
	Overall	123.0	134.5	144.3	21.3	21.3	0.80	1.73
42d CarcassWeight(g)	Males	145.5	153.4	163	17.5	17.5	0.66	1.20
	Females	150.3	162	172.6	22.3	22.3	0.71	1.48
	Overall	147.9	157.7	167.8	19.9	19.9	0.68	1.26
49d CarcassWeight(g)	Males	156	162.1	170	14.0	14.0	0.51	0.90
	Females	163.0	181.4	192.6	29.6	29.6	0.69	1.63
	Overall	159.5	171.75	181.3	4.8	21.8	0.60	1.27
56d CarcassWeight(g)	Males	174.6	185.1	198	23.4	23.4	0.74	1.26
	Females	190.2	206.8	225.7	35.5	35.5	0.99	1.72
	Overall	182.4	195.95	211.85	29.45	29.45	0.87	1.50

Δ**Gg** =response to selection; I=selection differential; P_S=mean body weight of selection; P_0=mean body weight of population; % I= percent selection differencial; % ΔGg= percent response to selection

Table.4.20: Response to selection in Mineral composition in meat of Japanese quail by sex

Traits	Sex	P_s	P_0	P_1	I	ΔGg	% I	% ΔGg
Ca	Males	0.86	0.88	0.91	0.05	0.05	0.35	0.57
	Females	0.82	0.84	0.88	0.06	0.06	0.49	0.71
	Overall	0.84	0.86	0.90	0.06	0.06	0.48	0.70
Mg	Males	0.66	0.67	0.68	0.01	0.02	0.15	0.30
	Females	0.77	0.77	0.78	0.01	0.02	0.13	0.26
	Overall	0.72	0.72	0.73	0.01	0.02	0.14	0.27
Fe	Males	1.56	1.52	1.53	0.03	-0.03	0.06	0.20
	Females	1.49	1.32	1.09	0.40	-0.40	1.54	0.30
	Overall	1.53	1.42	1.31	0.21	-0.22	0.72	1.55
Zn	Males	0.78	0.82	0.83	0.05	0.05	0.13	0.61
	Females	0.34	0.35	0.41	0.07	0.07	1.76	2.00
	Overall	0.56	0.59	0.62	0.06	0.06	0.54	1.02
Na	Males	0.04	0.04	0.05	0.01	0.02	2.50	4.00
	Females	0.06	0.06	0.07	0.01	0.02	1.67	2.86
	Overall	0.05	0.05	0.06	0.01	0.02	2.00	3.33
K	Males	2.03	2.06	2.08	0.05	0.05	0.10	0.24
	Females	2.04	2.02	2.06	0.92	0.02	1.96	0.10
	Overall	2.04	0.04	0.07	0.49	-0.97	0.15	0.05
P	Males	0.80	0.76	0.71	0.09	-0.09	0.63	0.12
	Females	0.71	0.80	0.79	0.08	0.08	0.14	1.00
	Overall	0.76	0.78	0.75	0.09	-0.01	0.39	0.13

Δ**Gg** =response to genetic improvement; I= selection differential; P_S=mean body weight of selection; P_0=mean body weight of population; % I= percent selection differencial; % ΔGg= percent response to selection.

Table 4.21: Response to chemical composition improvement for meat of Japanese quail by Sex

Traits	Sex	P_s	P_0	P_1	I	ΔGg	% I	% ΔGg
DM	Males	80.76	77.77	72.72	-2.99	-8.04	0.37	1.03
	Females	83.33	84.61	86.47	1.28	3.12	0.15	0.37
	Overall	82.05	81.19	79.60	-0.86	-2.45	0.10	0.30
Cp	Males	20.56	22.56	29.43	8.87	8.87	4.31	3.93
	Females	23.31	22.68	22.87	-0.63	-0.44	0.27	0.19
	Overall	21.94	22.62	26.15	0.68	4.21	0.31	1.86
Oil	Males	27.44	28.00	30.76	0.56	3.32	0.20	1.19
	Females	27.45	30.76	32.00	3.31	4.55	1.21	1.48
	Overall	27.45	29.38	31.38	1.93	3.93	0.70	1.34
Ash	Males	6.10	6.77	7.43	0.67	1.33	1.10	1.96
	Females	6.50	7.30	7.75	0.20	1.25	0.31	1.71
	Overall	6.30	7.04	7.59	0.74	1.29	1.17	1.83
NFE	Males	43.90	42.67	42.38	-1.23	-1.52	0.28	0.36
	Females	41.74	42.26	43.38	1.52	1.64	0.36	0.31
	Overall	42.82	42.47	42.88	-1.35	0.06	0.32	0.26

DM=dry matter; Cp=crude protein NFE= Nitrogen free extract, Δ**Gg** =response to selection for genetic improvement; I= selection differential; P_S=mean body weight of selection; P_0=mean body weight of population; % I= percent selection differencial; % ΔGg= percent response to selection, h^2= heritability

4.7 Realized Heritability in Traits of Japanese Quail

4.7.1 Heritability estimate based on individual selection for body weight in Japanese quail.

The realized heritability based on individual selection for body weight in Japanese quail (Table 4.22) was moderate (h^2= 0.27-0.38) except in G_I with the heritability increasing with increase in the generation of selection.

4.7.2 Heritability estimates of body weight at different ages of growth in Japanese quail

The heritability estimates for body weight at different ages of growth in Japanese quail (Table 4.23) was moderate to high (h^2 = 0.25 - 1.08), and was observed to decrease with increase in age of selection of the birds.

4.7.3 Heritability estimates of female sexual reproductive traits in female quail

The heritability estimates of reproductive traits in female quail is shown in Table 4.24. The h^2estimates for reproductive traits ranged from low to high (h^2 = 0.11 to 0.87) with egg weight having the lowest h^2 and pectoral major weight having the highest h^2.

Table 4.22: Realized Heritability based on individual selection for body weight in Japanese quail in two generations

Generation	I	ΔGg	h^2
G_0	26.43	7.14	0.27
G_1	20.67	7.93	0.38

ΔGg= response to selection; G_0= base population, G1=generation of offspring, I= selection differentail, h^2= heritability

4.23: Heritability estimates of body weight at different ages of growth in Japanese quail

Traits	I	ΔGg	h^2
Body Weight $_{35}$	13.04	13.28	1.08
Body Weight $_{42}$	12.28	10.43	0.85
Body Weight $_{49}$	6.64	2.43	0.37
Body Weight $_{56}$	14.10	33.50	0.25

ΔGg= response to selection; I= selection differentail, h^2= heritability

Table 4.24: Heritability estimates of female sexual reproductive traits in Japanese quail at sexual maturity

Traits	I	ΔG	h^2
35d Body weight (g)	10.40	1.08	0.10
Age (d)	1.62	0.68	0.42
Body weight (g) at sexual	10.64	0.32	0.03
Egg Weight (g)	1.76	0.20	0.11
Follicle Number (n)	5.92	0.72	0.12
Follicle size (cm)	5.74	1.32	0.23
Oviduct Weight (g)	1.80	0.60	0.33
Ovary Weight (g)	2.12	0.44	0.21
Pectoral Major Weight (g)	6.72	5.84	0.87
Abdominal fat Weight (g)	0.82	0.30	0.37

ΔGg= response to selection; I= selection differentail, h^2= heritability

4.7.4 Heritability estimates of male sexual reproductive traits

Table 4.25 shows the heritability estimates for reproductive traits in male quail at sexual maturity. The testicular weight and abdominal fat weight had very low heritability (0.05 and 0.06, respectively, while the body weight at 35 days and at sexual maturity as well as pectoral major weight had high heritability.

4.7.5 Heritability estimates of egg quality traits in Japanese quail

The h^2 estimates of egg quality traits was high ($h^2 = 0.51 – 0.77$) except for yolk length and Albumen width which had ($h^2 = 0.24$) and low ($h^2 = 0.04$), respectively.

4.7.6 Heritability for egg production in Japanese quail.

The h^2 estimates for egg production increased with age of production to 49 day and decreased slightly thereafter (Table 4.27). The h^2 were 0.31, 0.55, 0.61 and 0.59 for age 35, 42, 49 and 56 day, respectively.

Table.4.25: Heritability estimates of sexual reproductive traits in male Japanese quail

Trait	I	ΔG	h^2
35d Body weight(g)	8.88	5.68	0.64
Age at Sexual Maturity (d)	1.98	0.56	0.28
Body weight at SM (g)	16.32	9.68	0.59
Testicular Weight at SM (g)	2.35	0.12	0.05
Pectoral Major Weight at SM (g)	10.88	8.63	0.79
Abdominal fat Weight at SM (g)	0.49	0.03	0.06

ΔGg= response to selection; I= selection differentail, h^2= heritability

Table.4.26: Heritability estimates of egg quality traits in Japanese quail

Trait	I	ΔGg	h^2
Egg weight	2.25	1.56	0.69
Egg Length	1.32	0.67	0.51
Egg width	1.32	0.81	0.61
Yolk weight	0.18	0.11	0.61
Yolk Length	0.58	0.02	0.24
Yolk width	0.16	0.14	0.63
Albumen weight	0.78	0.60	0.77
Albumen Length	0.21	0.13	0.62
Albumen width	0.72	0.03	0.04
Shell weight	0.05	0.03	0.60
Shell thickness	0.08	0.06	0.75

ΔGg= response to selection; I= selection differentail, h^2= heritability

Table 4.27: Heritability estimates for egg production at different

ages in Japanese quailEgg Production	I	ΔGg	h^2
Egg 35	77	24	0.31
Egg 42	82	45	0.55
Egg 49	163	99	0.61
Egg 56	59	35	0.59

ΔGg= response to selection; I= selection differentail, h^2= heritability

4.7.7 Heritability of carcass weight at different ages of growth in male Japanese quail

The h^2 of carcass weight of male Japanese quail was high (Table 4.28), with values heritability increasing with increase in age from 0.40 at day 35 to 1.81 at day 56 of selection.

4.7.8 Heritability estimates of mineral composition in meat of Japanese quail

The h^2 estimates of mineral composition in meat of male Japanese quails are shown in Table 4.29. The h^2 for the mineral composition was ranged low to high. The h^2 of Mg and Na was perfect (h^2=1.0).

4.7.9 Heritability estimates of chemical composition for meat of Japanese Quail

Table 4.30. shows the heritability estimates of chemical composition of the meat of male Japanese quail. The heritability estimates were high for DM, CP, Oil and Ash (h^2= 0.50 - 0.83) but low for NFE (h^2 = 0.19). The genetic improvement in the male quail meat chemical composition was highest for CP (6.87) followed by DM (5.05).The improvement was low for both Ash (0.66) and NFE (0.29).

Table 4. 28: Calculated heritability of carcass weight at different ages in male Japanese quail

Traits	I	ΔGg	h^2
Carcass $Weight_{35(g)}$	20.0	8.0	0.40
Carcass $Weight_{42\ (g)}$	17.5	9.6	0.55
Carcass $Weight_{49(g)}$	14.0	7.9	0.56
Carcass $Weight_{56(g)}$	23.4	12.9	1.81

ΔGg= response to selection; I= selection differentail, h^2= heritability

Table 4.29: Heritability estimates of mineral composition in meat of male Japanese quail

Traits	I	ΔGg	h^2
Ca	0.05	0.03	0.60
Mg	0.01	0.01	1.00
Fe	0.03	0.01	0.33
Zn	0.05	0.01	0.20
Na	0.01	0.01	1.00
K	0.05	0.02	0.04
P	0.09	0.05	0.56

ΔGg= response to selection; I= selection differentail, h^2= heritability

Table 4.30: Heritability estimates of chemical composition of male Japanese Quail meat

Traits	I	ΔGg	h^2
DM	8.04	5.05	0.63
Cp	8.87	6.87	0.77
Oil	3.32	2.76	0.83
Ash	1.33	0.66	0.50
NFE	1.52	0.29	0.19

ΔGg= response to selection; I= selection differentail, h^2= heritability

CHAPTER FIVE

5.0 DISCUSSION

5.1 Sexual Maturity Characteristics of Japanese Quail

The age at sexual maturity in females of Japanese quail in this study was significantly differet influence by generation of selection, with 42.3, 40.99 and 42.6 day for the base, first and second, respectively. This value were lower than the 56.04, 54.38 and 42.56 day reported for base, first and second generation by Magda *et al.* (2010).The first generation of selection in this study had relatively shorter age at sexual maturity than the base and second generation. This suggested that selection for improvement in age at sexual maturity was more effective at the first generation at selection. This was contrary to the findings of Magda *et al. (2010)* who reported shorter age at sexual maturity in the second generation of selection in females. Other researchers also reported significant variation in age at sexual maturity across generations of selection (Lilburn and Nestor 1994; Gebhardt Heinrich and Mark, 1995; Tahar, 2009). The earlier age at the first generation could probably be attributed to better body weight threshold requaired for initation of egg production.

Age at sexual maturity in males also differed significantly amongst generation like the females, the age at sexual maturity was relatively shorter in the 1st generation of selection than the base and 2nd generation of selection. However, the age at sexual maturity in males was lower than of the females. This suggested that the males matured earlier than the females. Based on the findings, it could be deduced that age at sexual maturity in both male and female Japanese quails differed significantly among generation

for the base, first and second generation of selection. Birds of the first generation reached sexual maturity earlier than those of the base and second generation.

Generally, generation of selection in this study increased both male and female sexual maturity characteristics except follicular number which decreased with generation of selection. Selection for increased in body weight resulted in increase in egg weight and follicular size but decreased follicular number. This corroborates the report of Nestor *et al* (2000) that selection for increased body weight resulted in decrease egg production. In other study, Marks (1991) reported that selection for increased body weight under different nutritional environment resulted in decreased abdominal and carcass fat. This is contrary to the findings in this study in which selection for increased body weight resulted in an increase in abdominal fat and pectoral major weight. It was also noted in this study that there is a negative relationship between follicular number and follicular size. This suggested that selection for increase egg number might result in decrease in egg size.

The carcass characteristics of the Japanese quail varied significantly across generations of selection, with the second generation having higher carcass characteristics than the base at first generation of selection probably on extent of better body weight.

5.2 Effect of sex on bodyweight

There was sexual dimorphism in body weight of Japanese quail in this study with the females been superior in body weight than the males. This agreed with previous studies (Caron and Minvielle, 1990; Toelle *et al*., 1991; Minvielle *et al.,* 2000, Vali *et al*., 2005., Saatci *et al*., 2006; Khaldari *et al*., 2010; Niarinc *et al*., 2010). The mean values

for body weight in this study were higher than those of Marks (1993); Syed *et al.* (1999) and Vali *et al.* (2005) in selected groups of Japanese quails. The females were consistently higher in body weight at 35, 42, 49 and 56 day of age. In all generations corroborating probably on extent of better body weight. the findings of Vali (2009) and Minviellle *et al* (2000) who reported that the body weight of female Japanese quails was higher at day 49, 56 and 63 days of age than the males. The average weight gain of the females (4.195g) was higher than that of the males (2.975g) from 35 to 56 days of age in generation two.

The observed sexual dimorphism may be due to testosterone hormone that is released at sexual maturity and is reported to cause decrease in growth rate of males (Hyankova *et al.* 2001). Another possible reason that was advanced for the sexual dimorphism in quails was that the large reproductive organs in females such as ovaries and oviducts appears to be main reason behind higher body weight in females than the males (Marks, 1993). However, Magda *et al* (2010) reported that body weight of males and females within the same generation were not significantly different. Also, sexual dimorphism was observed in carcass characteristics of the quails in this study The carcass weight, breast weight, drumstick +thigh weight as well as backbone weight of females showed higher figures than the males. This is consistent with other reports (Caron and Minvielle, 1990; Toelle *et al*., 1991; Minvielle *et al*., 2000 and Vali *et al*., 2005). However, the males showed higher percentages of carcass weight, abdominal fat and breast weight. This agreed with the earlier findings of Minvielle *et al*, (2005) and Caron and Minvielle, (1990). Contrary to the findings in this study, Yalcin et al (1995) reported non significant difference between female and male for breast as percentage of body

weight. Likewise, Genchev *et al.* (2008) and Aksit *et al.* (2003) reported non significant different between sex in breast percentage of Japanese quails. Also, contrary to the result of this study, Vali *et al* (2005) reported that females significantly had higher breast percentage than the males and that there was no significant difference between sexes in terms of drum + thigh percentage weight.

The increase in average body weights in females over males were 2.8, 12.5, 22.4 and 28.5g for 35, 42, 49 and 56 day of age, in G_2, respectively. This is comparable to the findings of Kumar *et al.* (2000) who reported that females of Japanese quail were heavier in body weight than males by 2.48, 4.11, 4.39 and 5.53g at 21, 28, 35 and 42 days of age, respectively.

5.3 Effect of Generation of Selection and Sex on body weight and Carcass Characteristics of Japanese Quails

Selection has an important role in genetic improvement in animal production. Individual selection is particularly indispensable in selection experiments for body weight (BW) in poultry (Baylan et al., 2009). Generations of selection for body weight at different ages in Japanese quail have been studied by many authors; Camci (1992) reported that five generations of selection for high 5-weeks BW resulted in increased in body weight from the 1st and 3rd generations, but this increase was steady during 3rd and then started to increase. Ulucak *et al.* (1997) also reported that five generations of selection for 5 week body weight in Japanese quails led to higher body weight in the following subsequent generations. Baylan and Uluocak (1999) explained that two generations of selection for 3rd -5th week's body weight in Japanese quail produced an increase in body weight. The findings in the present study were not different as two

generations of selection for 77 body weight significantly influence body of Japanese quails from 35 to 56th day of age. The mean body weights of the selected response were consistently higher than the unselected population from the day 35 to 56 studied. This agreed with the findings of Sakunthala Devi *et al.* (2010) and Mohammed *et al.* (2006) that generation of selection consistently influence body weight of Japanese quails from day old to 16 weeks of age. The differences in the body weight across generation of selection may be due to differential expression of genes in the different generations, since the management conditions employed were similar across generation of selection. This shows that Japanese quails responds very quickly to selection, especially for improve body weight. In this study, selection for improved body weight at 35, 42, 49 and 56d in the first generation resulted in an improvement of 11.33, 13.28, 12.29 and 16.39g, respectively, while the improvement in the second generation was 10.59, 9.40, 11.87 and 18.63g, for day 35, 42, 49 and 56, respectively. Other earlier researchers reported varying levels of genetic improvement on selection of body weight Khaldari *et al.* (2010) recorded a genetic improvement at 4 weeks body weight as 9.6, 8.8 and 8.2g for Generations 2, 3 and 4, respectively in Japanese quails. In the most recent studies, Akrum *et al.* (2012) observed significant differences between two generations of Japanese quails being selected for four week body weight through mass selection procedures. Hussain *et al.* (2013) observed significant differences between four generations in selection of Japanese quails with superior body weight observed on birds of generation 2 and beyond. The different responses to selection in different experiments can be due to selection intensity, accuracy of selection, genetic variance and different environmental conditions.

There was also sexual dimorphism in body weight and carcass characteristics of Japanese quails, with the females having higher body weight, carcass weight and breast weight, as well as drumstick + thigh weight and % carcass weight, abdominal fat weight, % abdominal fat weight and % breast weight. The observed sexual dimorphism in Japanese quails in terms of body weight and carcass characteristics agrees with the reports by many authors (Seker *et al.,* 2007; Banos *et al.,*2010, Khaldari *et al.,*2010; Alkan *et al.,* 2010; Ojedapo and Amao, 2014). These authors reported superiority of females in body weight and carcass weight than males. This divergence in body weight and carcass composition between the two sexes may be attributed to acceleration of weight gain by females just prior to laying their first egg (Ojedapo and Amao, 2014). Also, Caron *et al.* (1990) indicated that females grow faster and yield large muscle and more abdominal fat than males at the same age. The large reproductive organs in females, such as ovaries and oviducts had been incriminated as the main reason behind higher body weight in females than males (Mark, 1993; Chaudhary *et al.*, 1994). In addition, the growth and development of the two sexes at early ages and the functions of hormones and other regulators systems could also be partly responsible for the observed sexual dimorphism.

The significant higher breast weight and lower carcass % observed in females than males is in consonance with the reports of other authors (Vali *et al.,* 2005, Alkan *et al.,* 2010, Banos *et al.,* 2010). However, the difference between males and females for percentage breast weight were not significant. This agreed with the findings of Yalcin *et al.*(1995), Aksit *et al.*(2003) and Genchev *et al.*(2008). Also, Vali *et al.* (2000) reported body weight in female quails at day 35, 42, 49 and 63 to be 133.32, 160.59, 187.13 and

213.32g, respectively and in the male 128.12, 150.96, 167.78 and 177.94g, respectively. These values were similar to the ones obtained in this study. The findings in this study showed that the average live weight of the males were lesser than those of the females. This was similar to the findings of Vali *et al.* (2005) in range quails (Coturnix ypisilophorus) and Japanese quail (Cortunix coturnix japonica), Salim Kul *et al.* (2000) in Japanese quails Genchev *et al.* (2005) in farm and English- white breeds of quails and Banerjee, (2010) on Japanese quails. On the contrary, Ibrahim *et al.*(2009) and Seker *et al.* (2000) reported non significant difference in slaughter weight between sexes. The values for intestinal weight, liver, heart and lungs were also higher in female birds than males. This is in consonance with the findings of Salim Kul *et al.* (2000), Ozcelik *et al.* (1998) and Ayasan *et al.* (2000) who reported higher live weight, intestinal weight and lungs in females than males.

The average dressing percentage, that is the percentage of eviscerated carcass with respect to the live weight, also suggested that the values were higher for male birds in comparison to the female birds.This findings agree with that of Vali *et al.*(2005), Minvielle *et al.* (2000) and Barnerjee (2010).The weight of the abdominal fat weight was higher in females in comparison to that of the male birds in this study. However, the values obtained in this study for the males (5.4g) and females (5.6g) agreed with Barnerjee, (2010) who stated that abdominal fat weight in female was higher 8.89g comparable to that of male 8.77g reported by Barnerjee, (2010).

It was also observed in this study that there were significant sex differences in the visceral organs and other edible parts of the birds. Similar observation had earlier been reported by Seker *et al.*(2005) who observed significant sex variation in the edible parts

of Japanese quail with female birds having higher values then the males. Also, Mousa (1993) and Mohammed (1990) reported higher meat and giblet percentage for females than males. Ojedepo and Amao (2014) reported higher values for female quails with respective to heart weight, gizzard weight and live weight than males.

5.4 Breast Meat Quality of Japanese Quail

The quality of meat with regard to storage and processing depends on pH values and the water retention capacity. The pH of breast meat at 20min (pH_{20mins}) post slaughter was slightly higher in females than males and was observed to decrease with age post slaughter. This agreed with the findings of Genchev *et al.* (2010).That pH at 20min post-slaughter was higher than that of 24min post-slaughter. Decrease in pH values with time had also been reported by Genchev *et al.* (2010) and is probably due to glycogen content of the breast meat. It is acknowledged that the increased relative share of glycogen muscle fibres in muscle bundles enhanced reduction in meat pH (Van-Lenlgerken *et al.*, 2002).This is probably so because subsequent to the post slaughter anaerobic metabolic changes, the glycogen store of the muscles are gradually depleted, leading to lactic acid accumulation and this leads to decrease in pH. The pH value of the breast meat at 20 min post slaughter in this study was between 6.1 and 6.3.This agreed with the values of 6.2 – 6.3 reported by Riegel *et al.* (2003).The pH values determined 24 min (pH24 min) post-slaughter varied between and 5 and 9, being slightly lower than the 6.1 and 6.3 reported by Genchev *et al.* (2010).The pH value of meat depends on glycogen content in the muscle, and glycogen is highly influenced by the locomotive activity and the presence of stress factors in the pre-slaughter period (Genchev *et al.*, 2010).

The percentage drip loss obtained in this study did not differ significantly between sex, and was observed to be lower at day 35 and higher at day 42 of age. This observation contradicts the findings of Genchev *et al.* (2010) who reported decrease in % driploss from day 31 to 42 in both sexes, with the values slightly higher in females than males. The drip loss percentages of meat in this study varied from 0.4 to 0,8% and lower than the 0.6 and 1.07% reported by Genchev *et al.* (2010). The quality of raw meat in terms of storage and processing depends on its hydrophilic properties, such as water holding capacity (WHC) and water absorption capacity (WAC) of the meat (Genchev *et al.*, 2010). The WHC of pectoral major in this study was significantly higher in females than males, and was observed to increase with age of the birds. However, the WAC was similar in both sexes and was observed to decrease as the birds were getting older. This observation agreed with the report of Genchev *et al.* (2010) that the values of WHC were higher in females than males with the WHC increasing with age while WAC decreases with age. Also the values of the WHC and WAC in this study were within the values reported by Genchev *et al.(*2010).

The good WHC of the breast meat guarantees excellent technological properties of meat .The relatively lower WHC of the males pectoral muscles could be related to the slightly lower pH values. It has been reported that poultry meat with lower pH are characterized with lower WHC (Lonergan et al., 2003; Owens et al., 2000; Van Laack, 2000).The WHC of the pectoral major seems to increase with increase in the redness (a) of the meat and as well as the decrease in the lightness (L) of the meat. This suggested that the WHC is positively related to the Redness (a) and negatively related to the lightness (L) of the meat. On the other hand, the water absorption capacity (WAC) of the

pectoral major seems to be positively related to the lightness (L) and negatively related to the Redness (a) of the meat. Contrary to the findings in this study, Genchev *et al.* (2010) reported non relationship of WAC with lightness(L) of the meat.

The value of the lightness in female quail meat was higher than in the males. This agreed with the finding of Genchev *et al.* (2010), through the values obtained in this study were lower. Also, the decrease in the lightness of meat with age concord with the earlier findings of Riegel *et al.* (2003) and Genchev *et al.* (2010). The values of redness (a) of meat in this study were similar to the one reported by Genchev *et al.* (2010). Also the observed increase in the redness (a) of the Japanese quails meat with age agreed with the report of Genchev *et al.* (2010). However, the values of Redness in this study were not different between sexes.

The lower breast meat lightness (L) value in this study compared favourablely with other values obtained in literaturefor the same muscles in broiler chickens (Qiao *et al.,* 2001; Fletcher, 1999) and Turkey (Fraqueza *et al.,*2000; Lesiow and Kijowski, 2003) and could be explained with the morphological profile of the pectoral muscle in quails. The obtained values of redness (a) and yellowness (b) in this study are comparable to those published by Riegel *et al.* (2003) and Genchev *et al.* (2010) for Japanese quail breast meat but were considerably higher than those obtained in broiler chickens (Allen *et al.,* 1997; Qiao *et al.,* 2002). There was no variation in the yellowness and hue (h^o) of the breast meat in terms of sex and age. However, there was significant variation in the meat chroma (C^O) between sexes and ages of the birds. This agreed with the earlier reports of Genchev *et al.* (2010) in Japanese quails. The breast meat chroma (C^0) in this study increased with the age of the birds. Contrary to the finding of Genchev *et al.*(2010).

Cooking loss was significantly higher in males than females in this study. This agreed with the report of Genchev *et al.* (2010). However, the values obtained in this study for both males and females were lower than those reported by Genchev *et al.* (2010). Similarly, observed increase in cooking loss with the age of the bird had seen reported by Genchev *et al.* (2010), and is probably due to reduction in the chemical bonding between muscle water and the proteins. It was reported that only 10-15% of muscle water is chemically bond to protein and that the other amount (about 60-65%) is " free water" that is lost during cooking as a result of protein denaturation (Valkova-Yorgova *et al.*,2000).

5.5 Realized heritability estimates for body weight

Realized heritability (h^2) is usually calculated as ratio of selection response to selection differential. Improvement of response to selection depends on selection intensity, selection accuracy and genetic variance; and optimal response to selection is obtained by maximizing these factors, but it is not simultaneously possible (Varkoohi and Kavian (2014). In this study, realized h^2 for body weight (BW) after selection for 77 body weight over two generations was higher than in the first generation. This agreed with the reports of Baylan *et al* (2009). Magda *et al* (2010) that h^2 estimate increased with generation of selection up to the 3rd generation.

A wide range of h^2 estimates for body weight has been reported at different ages (Fisher *et al*., 1994; Kumar *et al*., 2001 Saatci *et al* 2002; Vali *et al*., 2005; Baylan *et al*., 2009; Akbas *et al*., 2004) and generations (Baylan *et al*., 2009; Baylan and Uluocak 1999; Magda *et al.*, 2010). These studies normally used body weight at different ages and generations, and often used different methods to estimate the heritability.

The $h^2$of bodyweight in this study ranged from 0.25 at day 56 to 1.08 at day 35. This is similar to the range of 0.42 to 1.08 reported by Adeogun and Adeoye (2004). The $h^2$of body weight in this study was highest at day 35 and then decreased with age. This observation corroborate the findings of Akbas *et al.* (2004) and Baglan *et al.* (2009) that h^2 estimates for body weight at different ages increase from week 1 to 5 and then decreased thereafter. The variation of h^2 estimates with ages of the bird explains the changes of genetic and phenotypic or environmental variance for weight over the ages. Although, it was evident by the h^2 estimates that the body weight of the bird can be improved through individual selection, however the suitable age in which high selection response can be achieved is at the 35 day. The decrease in the h^2 of the body weight from day 42 to 56 suggested that the phenotypic and environmental variances increased rapidly than the genetic variance as the birds are getting older. However, the weight at day 35 to 42 reflected the genetics of the birds as the key element if feeding and health care satisfactory.

The h^2 of body weight at day 35 and carcass weight at day 56 were 1.08 and 1.81, respectively. These values were outside the theoretical range. The limits of deviation of h^2 ranges between $0<h^2<1$ (Duzgunes *et al.*, 1996). If h^2 calculated according to phenotype is outside this limits, the condition may occur either due to environmental variation or inadequate representation of selected animals in the population (Baglan *et al.*, 2009). Also, Falconer (1960) reported that h^2 for a particular trait can take different values according to the population, environmental conditions surrounding the animals and the calculation method. In quail, Adeogun and Adeoye (2004) reported h^2 of 1.08 for body weight; Baglan *et al.* (2009) reported an h^2 of 1.06 for female body weight. Some

researchers reported negative values for h^2 (Kacak *et al*.,1995, Nestor *et al.,* 1995; Baglan 2003), while others reported moderate h^2 for body weight at various ages of growth (Tigali *et al.,* 1997; Saatci *et al.,* 2002; Akbas *et al.,* 2004 and Shokoohmand *et al.,* 2007). The differences in the h^2 estimates might be attributed to method of estimation, strain, environmental effects and sampling error due to small data set or sample size (Prado-Gonzalez *et al.,* 2003).

5.6 Heritability estimates for egg production and quality traits

The heritability estimates for egg weight in this study (0.69) was higher than the 0.48 and 0.25 reported respectively by Kocak *et al.* (1995) and Saatci *et al.* (2005), and the range of 0.48-0.59, reported by Francesch *et al.* (1997). Also the h^2 estimates of egg length and egg width in this study were higher than the 0.18 to 0.22, reported by Saatci *et al.,* (2008). The high h^2 estimates for most of the egg quality traits suggest that the direct genetic effect makes larger contribution to the variability of the egg traits than the maternal permanent environmental effects. Therefore, egg quality of Japanese quails can be improved through selection. Likewise, the variability in egg production of the Japanese quails was more of genetic than environmental influences. However the magnitude of the genetic effect increased with increase in age of production to day 49 and then declined thereafter. The relatively higher h^2 estimate for day 49 of production might indicates an effective period in which high selection response for improved egg production can be achieved. Contrary to the findings in this study, Saatci *et al.* (2005) reported low h^2 of between 0.18 to 0.22 for egg quality characteristics. The values of h^2 estimates for egg weight (0.69), egg width (0.61), egg height (0.51), shell thickness (0.75) and shell weight (0.60) in this study are comparable to the values of egg weight (0.83),

egg width (0.68), egg height (0.72), shell thickness (0.53) and shell weight (0.08) reported by Sezer *et al.* (2007).

5.7 Heritability Estimates for Carcass Weight

The medium to high h^2 estimates for carcass weight suggested that the trait is genetically influenced more than environmental and can be improved through individual selection**.** However, the observed increase in the h^2 estimates of carcass weight with age indicated that the genetic variance increased considerably with increment in age of the birds (Akbas *et al.,* 2004). This observation suggested that selection for improvement on carcass weight in the birds should be made at the older age (day 56) than the younger age. Vali et al (2005) reported h^2 for carcass weight of 0.43 for Japanese quails. This agrees with the report of other researchers that h^2 for carcass traits in Japanese quails is moderate to high (El-Fikz 1991, Mousa; 1993 El-full *et al.,* 2001 and Mounsef 2005).

5.8 Heritability Estimates for male and female reproductive traits

The heritability estimates for age at sexual maturity (ASM) for females in this study (0.45) was slightly higher than the 0.30 and 0.33 reported by Abdel-Mounsef (2005) and Sezer *et al*. (2006), respectively. But the value of ASM for females in this study was far higher than the 0.19 and 0.11 reported by El-fiky et al (2000) and Aboul-Hussan (2001).

The h^2 value for AMS (0.28) for males in this study was similar to the 0.31, 0.28 and 0.24 reported by El-Dean (1994), Shebl *et al.* (1996) and Sezer *et al.* (2006), respectively. However, the value of Age sexual maturity for males in this study was lower than the 0.42 reported by El-fiky (1991). Magda *et al.* (2010) and Bahie El-Deen *et al.* (2008) reported that h^2 for age at sexual maturity ranged from 0.07 to 0.44. Based on

the findings in this study, it is evident that Age at sexual maturity is influence by both genetic and environmental factors depending on the age and generation of selection.

Testicular weight at sexual maturity, abdominal fat weight at sexual maturity, egg weight, follicle size, follicle number and oviduct weight low had h^2 estimates ranging from 0.12 to 0.21. This suggested that environmental effects make larger contribution to the variability on these reproductive traits than do the genetic effects. This implies that direct selection for these traits might not yield appreciable progress, thus rearing of the birds, health care and feeding management are very important determinants on these reproductive traits. However, pectoral major weight is a reproductive trait with high h^2 in both males (0.79) and females (0.87).

5.9 Heritability estimates of mineral and chemical composition of Japanese quail meat

The h^2 estimates of mineral and chemical composition of Japanese quail meat showed that the mineral and chemical composition of the meat the genetically driven rather than environmental or management and are highly heritable. The h^2 estimates for mineral and chemical composition in this study could not be compared with similar studies, because no published result was found for these parameters. Generally, most of the h^2 estimates in this study were within the biological limits except for some few estimates which were out of these limits. This might be due to sample size and method of estimation and environmental effects (Toelle *et al.,* 1991; Prado-Gonzalez *et al.,* 2003; Varkoohi and Kaviani, 2014).

The h^2 estimates for egg production and carcass weight increased with age from day 35, while the h^2 of body weight decreased from day 35, at the point when h^2 for egg

production was maximum. This probably suggested that body weight has negative genetic correlation with egg production and carcass weight. Therefore, selection for improvement in body weight might negatively affect the egg production of the birds. A study by Nester *et al.* (2000) reported that selection for increased body weight resulted in decreased egg production. Also, Marks (1991) reported that selection for increased body weight in Japanese quails under different nutritional environmental resulted in decreased hatchability and egg production. Therefore, it is obvious that increased genetic merit for body weight in quail is associated with reduced egg production. At the genetic level, two possible explanations have been put forward for this relationship. First, the pleiotropic gene effect suggest that gene could control more than one trait; such that genes that affect body weight also affect egg production. The second explanation is the linkage between genes, which suggest that genes which affect different traits are closely linked to each other at the chromosomal level (Falconer and Mackein, 1996).

CHAPTER SIX

6.1 CONCLUSION

The selection for 77 day body weight over two generations in the present study led to increase in body weight, body parts and body dimensions in female and male Japanese quail after selection at weekly interval .Body weight improvement was higher in females than males.

The Sexual maturity in female and male Japanese quail were reached earlier compared to other birds .Selection for high body weight led to increased egg weight but decreases in egg number and shell thickness. When birds slaughter at pH_{20} mins meat is near to neutral 5.0, but at pH_{24hr} rigor mortis occured which decreased beyound 6.0. Selection for body weight at day 56 lead to improvement in most of the economic important traits.

There was high heritability estimates for body weight at day 35 and 42. Like-wise for egg quality traits, egg production traits and chemical composition of Japanese quailmeat .The heritability estimates ranges between 0.38 to 0.80 for body weight at day 35 and 42.

6.2 RECOMENDATION

The suitable age in which selection response can be achieved is at earier age (day 35 and 42 d) for most of the economic traits in Japanese quail.

Further research on long time selection for body weight should be done to see the effect of response on the economic important traits in Japanese quail.

REFERENCE

Abdel- Mounsef, N.A. (2005). Non genetic factors affecting some productive traits in Japanese quail. Mansoura, *Journal ofAgricultural Science, 34:205-212*

Aboul-Hassan, M.A. (2001). Growth performance and natural selection of growth on Japanese quail as affected dietary energy sources, levels and age under the Egyptiian environmental condition.*Egypt poultry Science, 29(3):777-804*

Aboul-Hassan, M.A. (2000). Effect of slaughter age and sex on carcass composition of Japanese quail, *Poultry Science, 20:649-661*

Aboul-Hassan, M.A. (1997). Comparative study of growth traits in two strains of Japanese quail. *Journal Agricultural Resource& Development, 14:189- 197.*

Aboul-Hassan, M.A. (1995). Selection for growth traits in Japanese Quail.1-Early responses. Mansoura, *Journal of Agricultural Scienc., 22:101-109.*

Abplan, H., Woodward, A.E. and Wilson, W.O. (1967). The effects of unnatural day lengths upon maturation and egg production of the Japanese quail (Coturnix coturnix japonica). *Poultry Science, 41:1963-1968.*

Adeogun, I.O. and Adeoye, A.A. (2004). Heritability and phenotypic correlations of growth performance traits in Japanese quails. Livestock Research for Rural Development, pages 12-16

Aggrey, S.A. and Cheng, K.M. (1994). Animal Model analysis of genetic (Co) Variance for growth traits in Japanese quails. *Poultry Science, 73: 1822-1828.*

Ajay-Kumar, A.S.B., Verma, M.M. and Mandal, K.G. (2000). Effect of sex on body weight and conformation traits in selected and control lines of Japanese quail. *Indian Veterinary Journal, 77:325-327.*

Akbas, Y., Takma, C. and Yaylak, E. (*2004).* Genetic parameters for quail body weights using a random regression model. *South Africa Journal Animal Science,* 34:104–109.

Akbas,Y. and Yaylak, K. (2001). Heritability estimates of growth curve parameter, phenotypic and genetic correlation among growth curve parameters and the correlation of the parameters with weights at different ages of Japanese quail. *Arch geflugelk 64:141-146.*

Akpa, G.N., Kaye, J., Adeyinka, I.A. and Kabir, M. (2008). The relationships between laying age and repeatability of egg quality traits in Japanese quail(*Coturnix coturnix japonica).International Journal of Poultry Science, 7(6):555-559.*

Akpa, G.N., Kaye, J., Adeyinka, I.A. and Kabir, M. (2006). Repeatability of body weight and egg traits in Japanese quail. *Savannah Journal of Agriculture Volume 1 Number 2.*

Akpa, G.N., Asiribo, O.E., Oni, O.O., Alawa, J.P., Dim, N.I., Osinowo, O.A. and Abubakar, B.Y. (2002). Milk Production agrospastoral red Sokoto goats in Nigeria. *Tropical Animal Health and Production, 34 (6): 523-533.*

Aksit, K., Shouky, H.M.S. and Leeson, S. (2003). Commercial Poultry Nutrition, University Books. Guelph, Ontario, Canada pp. 888-899.

Alkan, S., K. Karaban, A. (2010). Determination of body weight and some carcass traits in Japanese quails *(Coturnix coturnix japonica)* of different lines. Kafkas. *University Veterinary. Fak. Derg 16(2): 277-280.*

Akrum, A.E.H., Shamma, T.A. and Mabrouk, M.M.S. (2012). Heritability estimates phenotypic and genetic correlation among some traits in Coturnix coturnix Japonica. Al- Azhar Journal Agriculture Volume (VI): 265-275.

Allen, C.D., Russel, S.M. and Flecther, D.L. (1997). The relationship of broiler breast meat color and pH to shelf-life and odor development. *Poultry Science, 76(1): 42-46.*

Altinel, A., Gunes, Kirmizibayak, H.T., Corekci, S.G. and Bilal, T. (1996). The studies on egg quality characteristics of Japanese quails. *Veteriner Fakultesi Dergisi Istanbul 22:203-213.*

Anthony, N.B., Nestor, K.E. and Marks, H.L. (1996).Short-term selection for four-week body weight in Japanese quail. *Poultry Science, 75:1192-1197.*

Annaka, A., Momose, K., Tomizawa, Y., Watabe, E. and Ishibasi, T. (1993). Effects of dietary protein level on performance of Japanese quail. *Animal Science and Technology, 64:797-806.*

AOAC.(2000). Official Methods of Analysis: Fat or Ether extract in Meat.15th ed. Association of Official Chemists, Washington DC.

Arjun-Kumar, K.M., Pratap-Kumar, K.S., Ramappa, B.S. and Manjunath, A. (1990). Influence of parental age on fertility, hatchability, body weight and survivability of Japanese quail.Poultry Adviser XXII (Issue IX) Pages, 103-142

Ashok, A. and Prabakaran, R. (*2012*). Evaluation of Growth Traits in short term selection for different ages in Japanese quail. *Indian Journal of Fundamental and Applied Life Sciences Volume* 2 (1) 152 -157

Ayasan, S. E., Reddy, A. R. and Cheng, K. M. (2000). Animal model analysis of generic (co) variance for growth traits in Japanese quail. *Poultry Science, 73: 1822-1828.*

Bacon, W. L. and K. E. Nestor, (1983). Reproductive response to intermittent light regimens in (*Coturnix coturnix japonica*) *Poultry Science,* 54:1918-26.

Banner, F., Kızılkaya, K., Balcıoğlu, S.,Yolcu, H.I. and Karabağ, K. (2010). The application of exponential method in the analysis of growth curve for Japanese quail. *Arch. Geflügelk. 69 (4) 23-29*

Banerjee, G., Hyankova, L., Knizetova, H., Dedkova, L. and Hort, J. (2010). Divergent selection in shape of growth curve in Japanese quail 1. Responses in growth parameters and food conversion. Poultry Science, 42, 583-589.

Bahie El-Dean M, El-Tahawy WS, Attia YA, Meky MA, (2008). Inheritance of age at sexual maturity and its relationships with some production traits of Japanese quails. Egyptian Poultry Science 28: 1217-1232

Bahie El Deen, M. (1994). Selection indices and crossing as a tool for improvement meat and egg production in Japanese quail. Ph. D. Thesis, Faculty of Agriculture, Alexandria. University, Egypt.

Balcioglu, M. S., Kilzilkaya, K., Yolcu, H.I. and Karabag, K. (2005). Analysis of growth characteristics in short term divergently selected Japanese quail. *South Africa Journal of Animal Science,* 35(2): 84-89.

Banos, W.L., Nestor, K.E., Renner, P.A. (2010). The influence of genetic increases in body weight and shank width on the abdominal fat päd and carcass composition of Japanese quail. Poultry Science 65, 391-397

Baik, D.H. and Marks, H.L. (1991). Divergent selection for growth in Japanese quail under split and complete nutritional environments.7.Heterosis and combining ability among dialed crosses following 27 generations of selection. *Poultry Science, 72: 1449-1458.*

Barbut, S. (1997).Problem of pale soft exudative meat in broiler chickens.Br. *Poultry Science, 38:355-358.*

Barbut, S., Zhang, L. and Mcircone, M. (2005). Effects of pale, normal and dark chicken breast meat on microstructure, extractable proteins, and cooking of marinated fillets.*Poultry Science,84:797- 802.*

Baumgartner, J. (1990). Japanese quail as laboratory animal (in Solvak). Publishing House of Solvak Academy of Science , Bratislava PAGES 128-135.

Baumgartner, J. (1994).Japanese quail production, breeding and genetics. *World's Poultry Science, Journal, 50:227-235.*

Baumgartner, J., Palanska, O. and Koncekova, Z. (1990). Technological quality and nutritive value of meat of English white quail. Hydinarstvo, Ivanka pri Dunaji, CSFR, 25, 97-107.

Baumgartner, J., Palanska, O. and Koncekova, Z. (1987). Comparative performance of Japanese quail on cage and deep litter (1) Body weight, feed efficiency and mortality. *Indian Journal of Poultry Science* 20 (3) :162-164

Baylan, M., Canogullari, S.,Sahin, Capur, G and Baylan, M. (2009). Effect of different selection methods for body weight on some genetic parameters in Japanese equail. *Journal of Animal and Veterinary Advances 8 (7): 1385- 1391.*

Baylan, M. (2003). Effects of productivity of divergent selection methods according to body weight in Japanese quail. *http:// fenbilimeri.mku.edu.tr/tezadi.htm.*

Baylan, M. and Uluocak, A.N. (1999). Productivity of selection for body weight at different ages in Japanese quail. Pages 626-632: In Proceeding Internatinal *Poultry Fair conference*, Istanbul, Turkey.IPFC 99,Yutav.

Behie, E. M., El-Tahawy, W. S., Attia,Y. A. and Meky, M. A. (2009). Inheritance of age at sexual naturity and its relationship with some production traits.*Poultry Science. 28 (1V) : 1217-1232.*

Brody, S. (1945). Bioenergetics and growth. Reinhold Pub. Crop.,New York,N.T.

Camci, O., Erensayin, C. and Akan, S. (2002). Relations between age at sexual maturity and some production characteristics in quails. *Arch. Geflugelk., 66:280-282.*

Camci, O (1992) Changing of body composition by selection in Japanese quail (*Coturnix coturnix japonica*).*Technology Poultry Magazine* 75:52-61

Caron, N. and Minvielle, F. (1990). Mass selections for 45 day body weight in Japanese quail.Selection response carcass composition, cooking properties and sensory characteristics. *Poultry Science, 69:1037-1045.*

Cerit, H. (1997). Genetic and phenotypic parameters of various traits in the Japanese quail (*Coturnix coturnix japonica*). *http/Istanbul/tky. Edu/tezadi.htm.*

Chaudhary, M.L., Brah, G.S., Sandhu, J.S. and Saijpaul, S. (1999). Comparison of two lines of Japanese quails and their reciprocal crosses for body weight egg quality. *Indian J. of poultry Science, 34:147-154.*

Chidananda, B. L., Prathapkumar, K. S., Sreenivasaiah, P.V., Lokanath, G.R. and Ramappa, B. S. (1986). Comparitive performance of Japanese quail on cage and deep litter (1) Body weight, feed efficiency and mortality. *Indian Journal of Poultry Science* 20 (3) 162-164.

Collins, W. M., Swanson, J. M. and Urban, J. W. E. *(1968)*. Selection for body weight at three weeks of age in *Coturnix*. *Poultry Science. 47 (Supplementation 1):1661. (Abstract.)*

Collins, F. and Abplanalp, H. (1967). Genetic parameters of some productive and reproductive traits in Japanese quail. *Enviromental Arid Land Agriculture, Science,5: 45-60*

Collins, W.M. and Abplanalp, H. (1965). Mass selection for body weight in Japanese quail. *Genetics 52:436-437.*

Darden, J. R. and Marks, H. L. (1988). Divergent Selection for growth in Japanese quail under split and complete nutritional environments. Water and feed intake patterns, abdominal fat and carcass lipid characteristics. *Poultry Science, 67:1111-1122.*

Daum-Thunberg, J.J. Verma., K. and Sales, J. (1997). Growth rate of different sexes of the European quail (*Coturnix cortunix japonica*).*British Poultry Science, 38:314-317.*

Dhaliwal, S.K., Choudhary, M.L., Brah, G.S. and Sandhu, J.S. (2004). Growth and Carcass characteristics of selected and control lines of Japanese quails. *Indian Journal of Poultry Science 39 (2) 112-119.*

Drbohlav, V. and Metodiev, S. (1997). Relationships between some fattening and slaughter traits in Japanese quails (*Coturnix coturnix Japonica*). *Animal Science* (Sofia), supplement, 159-162.

Drbohlav, V. and Drbohlavova, D. (1989). Effect of storage upon meat quality traits in broiler chickens. Food Production Science, III, 1:25-29.

Duncan, D. B. (1955). Multiple range and multiple F Test.*Biometrics., 11:1-42.*

Dunnington, E. A. and Siegel, P. B. (1984). Age and body weight at sexual maturity in female White Leghorn chickens. *Poultry Science, 63: 82-830*.

Duzgunes, O., Elici, A. and Akman, N. (1996). Animal amelioration, University of Ankara, Publication of Agriculture, Faculty. Ankara Turkey. ISBN975-482-304-9.

El-Deen, H., Abdelnabi, M. and Ragheb, G. (1994). Effect of age, body weight and sex ratio on fertility, hatchability and egg production in the Japanese quail (Coturnix coturnix japonica) under subtropical conditions. Assiut University, College of agriculture, Animal and Avian Production Dept. Egypt. *Poultry Science 80 (Abstract) page 264.*

El-fiky, F.A. (2005).Selection for high body weight at six weeks of age in Japanese quail. Direct and correlated responses. *Al-Azhar Journal of Agriculture, Resources.5(4):43-47*

El-Fiky, F.A. (1991). Genetic studies on some economic traits in Japanese quail Al-Azhar Journal of *Agricultural Resources, 19:111-121.*

El-Fiky, F.A., Shamma, T.A. and El-Oksh, H.A. (1994).Genetic parameters of some productive and reproductive traits in Japanese quail. *Enviromental Arid Land Agriculture, Science, 5:45-60*

El-Fiky, F.A., Aboul-Hassan, M.A., Batta, S.S. and Attalah, G.E.Y. (2000). Comparative study of egg production traits in two strains of Japanese quail. *Fayoum Journal of Agriculture, Res. and Development, 14:198-205.*

El-Full, E.A., Ali, A.A., Abdel-Fattah, M.H. and Khalifa, M.A. (2001).Genetic parameters of some carcass characteristics and chemical composition in Japanese quail, *Journal Poultry Science.,1:741-763.*

EL-Ibiary, H.M., E.F. and Shaffner, C.S. (1966). Correlations between growth and reproductive traits in the Japanese quail. *Poultry Science, 45:463-469.*

Falconer, D.S. (1989). Introduction to quantitative genetics.3rd ed Longman Group, Essex, England.

Falconer, D.S. and Mackay, T.F.C. (1996). Introduction to Quantitative Genetics. 4th Edition, Longman Group, Essex, England.

Falconer, D.S. (1960). Selection of mice for growth on high and low planes of nutrition. *Genetic* Resources Combination, 1: 91-113.

Fisher, A.V., Green, D.M., Whitemore, C.T., Wood, I.D. and Schofield, C.P. (2003). Growth of carcass components and relation with conformation in pigs of three types. M*eat Science,* 65:639-650.

Fisher, C. (1984) Protein deposition in poultry. Pages 251-270 in Protein Deposition in Animals P.J. Buttery and D.B. Lindsay, ed. Butter worths, London, UK.

Fletcher, D.L.(1999). Broiler breast meat color variation, pH, and texture. *Poultry Science,* 78:1323-1327.

Fletcher D.L. (2002). Poultry meat quality. World's Poultry Science, 58, 2:131-145.

Francesh, E., Paul, G. and Marks, H.L. (1997). Growth curve changes associated with long-term selection for body weight in Japanese quail. Growth, 42: 129-140.

Fraqueza, M.J., Cardoso, A.A., Ferreira, M.C. and Barreto, A.S. (2000). Incidence of pectoralis major Turkey muscles with light and Dark colour in a Portuguese slaughter house. *Poultry Science, 85:676-682.*

Fraqueza, M.J., Cardoso, A.S., Ferreira, M.C. and Barreto, A.S. (2006). Incidence of Pectoralis Major Turkey Muscles with Light and Dark Color in a Portuguese Slaughterhouse. *Poultry Science*, 95: 62- 70.

Gebhardt-Henrich, S.G. and Marks, H.L. (1995). Effects of feed restriction on growth and reproduction in random bred and selected lines of Japanese quail. *Poultry Science,74:402-406.*

Genchev, A. Mihaylov, R. And Dinkov, D. (2008). Slaughter analysis protocol in experiments using Japanese quails *(Coturnix coturnix Japonica)*. *Trakia Journal of Sciences,* 6, 4: 66-71.

Genchev A., Pavlov, A., Kabakchiev, M. S., Ribarski, G. and Michailova, G. (2007). Effect of forage supplementation with calcium peroxide on the growth and meat quality of Japanese quail. *Journal of Animal Science, 4:29-34.*

Genchev A.G., Ribarski, S.S., Afanasjev, G.D. and Blohin, G.I. (2005). Fattening capacities and meat quality of Japanese quails of Faraon and White English breeds. *Journal Central European Agriculture, volume 6, No 4:501-505.*

Genchev, A., Ribarski, S., Michailova, G. and Dinkov, D. (2004). Slaughter characteristics and chemical composition of the meat from Japanese quail (Coturnix coturnixjaponica). Journal of Animal Science, 5:8-12.

Genchev, A. (2003). Fatting capacity and meat quality of Japanese quail fatted with mixed fodder with different nutritive values. *Journal of Animal Science, 5:54-57.*

Ghany, M. A., Godfrey, E.F. and Hull, H.L. (1996). Growth curve changes associated with long-term selection for body weight in Japanese quail. Growth, *Poult. Science, 45: 1422.*

Gildersleeve, R.P., Parthurst, D., Sugg, C.R. and Mc Ree, D.I. (1987). Egg production in four generations of paired Japanese quail. *Poultry Sci. 66: 227-230.*

Hashiguchi, M., Mahipala, M.B.P. and Kamisoyama, H. (1998). Influence of low protein diets on sexual maturity and body characteristics in female Japanese quail. Proceedings of 6thAsian Pacific PoulrY, Congress, 408-409.

Helal, M.A. (1995). The effect of crossing on the performance of Japanese quail *Mansoura, J. of Agricultural Science, 34:147-154.*

Hussein, S.A., Jamilah, M. and Hassan, D. (2013). Performance of crosses of two quail lines selected for high body weight. Proceeding of the Silver Jubilee Malasian Society of Animal Production (MSAP), *May 28-31, 2013, Sarawak, Malaysia;* pages 221-213.

Hussein, A.S., Canton, A.H., Pescatore, A.J. and Johnson, T.H. (1996).Effect of dietary protein and energy levels of Japanese quail.*poult.Science,75:973-978.*

Hyankova, L., Knizetova, H., Dedkova, L. and Hort , J. (2001). Divergent selection shape of growth curve in Japanese quail 1. Responses in Growth parameters and food conversion. British *Poultry Science, 42 : 583-589.*

Ibrahim, S.D., Dutta, O.Q., Agarwal, S.K. Kataria, M.C. (2009). Genetic parameter estimates of slaughter traits in Japanese quail. Estimates on observed traits. Avian Research, 67, 9-12

Imai, C., A. Mowlah and Saito, J. (1986). Storage stability of Japanese quail (*Coturinx coturnix japonica*) egg at room temperature. *Poultry Science, 65: 474-480.*

Ina, S., Dere, S., Kiiriikcii, K. and Tepeli, C. (1996). The effects of selection for body weight of Japanese quail on egg production, egg- weight, fertility, hatchability and survivability, *Vetetinary Bilimleri Dergisi.,12:13-22.*

Jaap, R. G. (1963). Selection for rapid growth rate in chickens. *Poultry Science,. 42: 1393- 1397.*

Janda, M.M. (1977). Quail Production Systems, A Review.Published by FAO, Rome, Italy.

Jensen, H., Saether, B.E., Ringsby, T.H., Tufo, J., Griffithy, S.C. and Ellergren, H. (2003). Sexual variation in heritability and genetic correlations of morphological traits in House Sparrow*(Passer domistica). Journal of Evolution Biology,16:1296-1307.*

Jones, J.E., Hughes., B.L. and Barnett., B.D. (1979). Effect of changing dietary energy levels and environmental temperatures on feed consumption and egg production of single comb white Leghorns. *Poultry Science Journal*., 55: 274277.

Kocak C, Altan O and Akbas Y (1995). An investigation on performance traits in the Japanese quail. *Turkish Veterinerlik ve Hayvancilik Dergisi* 19 65-71. Cited from *CAB Abstract* (1995).

Kaitazov G. and Genchev, A. (2004). Influence of the fattening period duration in Japanese quails on the efficiency of production. Journal of Animal Science, 5:13-17

Kawahara, T. and Saito, K. (1976). Genetic parameters of organ and body weight in Japanese quail,*Poultry Science, 55:1247-1252.*

Kesici, T., Kavuncu, O., Ozkan, M.M. and Yildiz, M.A. (1998). Correlated Response of fitness to selection for 5-weeks body weight in Japanese quail (*Coturnix coturnix japonica*). II Later Results Book of Abstract of the 47th Annual meeting of the European Association for Animal Production. *Lille hammer 25-29 August Norway, Poster G_2. 36, Pp:30.*

Khaldari, M., Pakdel, A., Mehrabani, H., Nejati A. and Berg, P.(2010). Response to selection and genetic parameters of body and carcass weights in Japanese quail selection for 4-week body weight. *Poultry Science, 59(9):1824-1841.*

Kijowski, M. and Niewiawmic, H.L. (1998). Growth curve changes associated with long-term selection for body weight in Japanese quail. *Growth 42, 129-140.*

Kijowski, J. and Niewiarowicz, A. (1978). Emmusifying properties of protein and meat from broiler breast muscles affected by their initial pH values. *Journal of Food Tech; 13:451-459.*

Kilkpinar, F. and Oguz, I. (1995). Influence of various dietary protein levels on carcass composition on the male quail (*Coturnix coturnix japonica*). *British Poultry Science, 36:605-610.*

Kim, S.M. and McGinnis, J. (1976).Effect of levels and sources of dietary protein in pullet grower diet in subsequent performance.*Poultry Science, 55:895-905.*

Kinney, T.B., Jr. (1969). A summary of reported estimates of heritabilities and of genetic and phenotypic correlations for traits of chickens. USDA. Agriculture Handbook, page 363.

Kocak, C., Altan, O. and Akbas, Y. (1995). An investigation on performance traits in the Japanese quail.*Turk Veterinerlik ve Hayvancilik Dergisi* 19 65-71. Cited from *CAB Abstract* (1995).

Kul, S. and Seker, I. (2004). Phenotypic correlation between some external and internal egg quality traits in the Japanese quails. *International Journal Poultry Science, 3: 400-405*

Kumar , K.M.A. (2000). Influence of parental age on fertility , hatchability , body weight and survivability of Japanese quail . Poultry .Adviser , 77 : 73- 75. (Cited in CAB Abstract) .

Kumar, A.S.B., Verma, M.M. and Mandal, K.G. (2000). Effect of sex on body weight and conformation traits in selected and control lines of Japanese quail. *Indian Vetetinary. 77:325-327.*

Kumar, P.B., Gupta, B.R. Prakash, M.G. and Reddy, A.R. (2001). Genetic study on body weights of Japanese quails. Indian Journal of Poultry Science. Vol: 44 Issue: 3. (Abst).

Le Bihan-Dual, E. (2004). Genetic variability in poultry meat quality. *World's Poultry Science Journal*, 60, (3):331-340

Leenstra, F.R., Vereijken, P.F.G. and Pit, R. (1986). Fat deposition in a broiler sires strain. Phenotypic and genetic variation in and correlations between, abdominal fat, body weight and feed conversion. *Poultry Science 65: 1225-1235.*

Lesiow, T., 2000. Gelation of chicken breast and thigh muscle homogenates: Effect of pH and time of aging. Nahrung Food., 44:426-430.

Lesiow, T. and Kijowski, J. (2003) Impact of PSE and DFD meat on poultry processing – Review. Pol. J. Food Nutr. Sci., 12/53, 2:3-8.

Lilburn, K.S. and Nestor, K.E. (1994). Effect of selection for growth on onset of sexual maturity in random bred (RBC) and growth selected (HW) stains of Japanese quail.*Poultry Science73: 208. (Absrt).*

Lilburn, M.S. and Mayer-miller, D.J. (1990). Dietary effects on body composition and subsequent production characteristics in broiler hens. *Poultry Science 69:1126-1132.*

Lonergan, S.M., Deeb, N., Fedler, C.A. and Lamont, S.J. (2003). Breast meat quality and composition in unique chicken population. *Poultry Scence*, 82:1990-1994.

Magda, I. Abo Samaha., Sharaf, M.M. and Hemeda, Sh. A. (2010). Phenotypic and genetic estimates of some productive and reproductive traits in Japanese quails. Egypt. *Poultry. Science, 30: 875-892*.

Mandal, K.G., Sinha, R., Koley, N.P., Mohan, M., Verma, S.B. and Sharma, D. (1994). Effect of crossing on the performance of Japanese quail, Indian *Journal Poultry Science, 29:82.*

Marks, H.L. (1996). Long-term selection for body weight in Japanese quail under different environments. *Poultry Science, 75:1198-1203.*

Marks, H.L. (1993). Carcass composition, feed intake and feed efficiency following long-term selection for four-week body weight in Japanese quail.*Poultry Science, 72:1005-1011.*

Marks, H.L. (1991). Divergent selection for growth in Japanese quail under split and complete nutritional environment.4. Genetic and correlated responses from generations *12-20. Poultry Science,70: 453- 462.*

Marks, H.L. (1990). Abdominal fat and testes weights on different genetic lines Japanese quail. *Poultry Science, 69:1627-1633.*

Marks, H.L. (1989). Long-term selection for four-week body weight in Japanese quail following modification of the selection environment.*Poultry Science, 68:455-459.*

Marks, H.L. (1980). Reverse-selection in a Japanese quail line previously selected for 4-weeks body weight, *Poultry Science,59 (6): 1149-1154*.

Marks, H.L. (1975). Heritability discrepancies following long-term selection for body weight in quail. *Poultry Science,54:1787-1788.*

Marks, H.L. (1973). Performance of crosses of quail selected under different environments. *Journa of Hered, 64: 73-76.*

Marks, H.L. and Kinney, T. N. (1964). Phenotypic and genetic estimates of some productive and reproductive traits in Japanese quails. *Egyptian Poultry Science 30(3): 875-892*.

Mignon-Grasteau, S., David, J., Gibert, P., Legout, G., Petavy, G., Moretau, B. and Beaumont, C. (2004). REML estimates of genetic parameters of sexual dimorphism for wing and thorax length in Drosphila melanogaster. *Journal of Genetics, 83:163-170.*

Minvielle, F., Swiger, L.A., Harvey, W.R., Everson, D.O. and Gergory, K.E. (2005). The variance of interclass correlations involving groups with one observation. *Poultry Science 26 (IV): 71-85.* .

Minvielle F. (2004). The future of Japanese quail for research and production. *World's Poultry* Science Journal, 60, 4:500-507

Minvielle, F. and Oguz, Y. (2002). Effects of genetics and breeding on egg quaility of Japanese quail. *World's Poultry Science Journal,58 : 291-295*

Minvielle, F., Gandemer, G., Maeda, Y., Leborgne, C., Hirigoyen, E. and Boulay, M. (2000). Carcass characteristics of a heavy Japanese quail line under introgression with the rouxgene. *British Poultry Science, 41: 41-45.*

Minvielle, F., Hirnoven, F. and Boyky, M. (1999). Associate effects of the Roux plumage colour Mutation on growth Carcass traits egg production and reproduction of Japanese quail. *Poultry Science, 78:1479-1484.*

Minvielle, F. (1998). Genetics and breeding of Japanese quail for production around the world. In: Proceeding of the 6th Asian Pacific Poultry Congress, Nagoya, Japan *Poultry Science Association, Tsukuba, pp: 122-127*

Minvielle, F. and Oguz,Y. (1998). Effects of genetics and breeding on egg quality of Japanese quail *World's Poultry Science Journal, 56:291-295.*

Mohammed, F.A.(1990). Studies on proteins requirements of Japanese quail during growing and laying periods. *Http/www. Ad-Azharunivs.Edu.*

Mohammed, M.S.F., B.R. Gupta., R.G. Narasimha and R.A. Rajasekhar (2006). Genetic evaluation of the performance of Japanese quails. *Indian Journal Poultry Science,* 41:129-133.

Mounsef, M. (2005). Genetic parameters of body and egg weight in Japanese quails (Coturnix coturnix japonica) using partial diallel analysis. Egypt Poultry Science. 26 (IV): 1471-1485.

Mousa, K.R.N. (1993). The influence of different nutritional conditions on some genetic parameters in Japanese quail. *Http/www.mouse.Al-Azharuniv.Edu.*

Narahari, D., Aboulmujeer, K., Thangavel, A., Ramamurthy, N., Viswanathan, S., Mohan, B., Muruganandan, B. and Sundararasu, V. (1988). Traits influencing the hatching performance of Japanese quail eggs. *British Poultry Science.29:101-112.*

Narinc, D., Karaman, E. and Aksoy, T. (2010). Estimation of genetic parameters for carcass traits in Japanese quail using Bayesian methods.*S.African Journal Animal Science, Volume 40, Number 4.*

Narinc, D., Karaman, E., Aksoy, T., Firat, M. Z. and Tulin, A. (2010). Comparism of non-linear growth models to describe the growth in Japanese quail. *Journal of Animal and Vetinary Advance,9 (3),501-507.*

Nazliqul, A., Turkyilmaz, K. and Bardakcioglu, H.E. (2001). A study on some production traits and egg quality characteristics of Japanese quail. *Archivfur Geflugelkunde 68: 280-283.*

Nestor, K.E., Steigner, J.W. and Liburn, M.S. (2005). Growth and reproduction of lines of Japanese quail divergently selected for growth rate. *Poultry Science, 96:101-120.*

Nestor, K. E., J. W. Anderson, and R. A. Patterson. (2000). Effects of selection for increased BW, egg production, and shank width on developmental stability in turkeys. *Poultry Science,* 79: 937-945.

Nestor, K.E., Strong, C.F. Jr. and Bacon, W.L. (1995). Inheritance of egg production, egg weight, body weight and certain plasma constituents in *Coturnix. Poultry Science, 5:1-9* .

Nestor, K.E., Bacon, W. and Lambio, A.L. (1994). Divergent selection for egg production in *coturnix coturnix japonica*. *Poultry Science, 62:1548-1552.*

Nestor, K. and Bacon, W.L. (1982). Divergent selection for body weight and yolk precursor in Coturnix Coturnix Japonica. Correlated responses in mortality, reproduction traits and adult body weight. Journal Poultry Science, 61:2137-2142.

Nestor, K.L., Bacon, W.L. and Lambio, A.L.(1982). Divergent Selection and yolk precursor in *Coturnix coturnix japonica*.3.Correlated responses in mortality, reproduction traits and adult body weight.*Poultry Science, 61:2137-2142.*

Noda, K., Miyakawa, H., Nakamura, A., Mizuno, K. and Umezawa, Y. (2003). Genetic parameter estimate for egg weight and its related traits in Japanese quail. *Poultry Science, 40:66-70.*

Northcutt, J.K., Foegeding, E.A. and Edens, F.W. (1994). Water holding properties of thermally preconditioned chicken breast and leg meat. *Poultry Science, 73:308-316.*

N.R.C. (1994). National Research Council. Nutrient requirements of Poultry.9th ed. National Academy of Science, Washington, D.C.,USA.

Oguz, I., Asie, M., Onene, A., Gevrekci, Y., Ozdemir, D. and Altan, O. (2004). Genetic variability of meat quality characteristics in Japanese quail *(Coturnix coturnix japonica). Arch, Geflugelk., 68:176-181*.

Oguz, I. and Turkmut, L. (1999). Effects of selection for 4 weeks body weight on some parameters in Japanese quail (Coturnix coturnix japonica) 1. Genetic parameters. *Turkish Journal VeterinaryAnimal Science,* 23: 215-224.

Oguz, I., Attan, O., Kirkpinar, F. and Settar, P. (1996). Body weights, carcass characteristics, organ weights, abdominal fat and lipid content of liver and carcass, in two lines of Japanese quail (*Coturnix coturnix japonica*) unselected and selected for four week body weight. *British Poultry Science, 37:579-588.*

Ojedapo, L.O. and Amao, S.R. (2014). Evaluation the effect of age and sex on serological indices of Japanese quail (Coturnix coturnix japonica). Savanna Enviroment of Nigeria. Journal of Agriculture Science and Tecnology, Volume 5 number 1.

Oroian, T., Vlaic, A. and Cighi, V. (2002). Some aspects concerning the egg production performances in two Japanese quail varieties. Cited from *CAB Abstracts*, 2002.

Oruwari, B.M. and Brody. T. (1988). Roles of age, body weight and composition in the initiation of sexual maturation of Japanese quail (Coturnix coturnix japonica). British. Poultry Science, 29:481-488.

Owens, C.M., McKee, S.R., Matthews, N.S. and Sams, A.R. (2000). The development of pale, exudative meat in two genetic lines of turkeys subjected to heat stress and its prediction by halothane screening. *Poultry Sci*ence, 79: 430-435.

Ozcelik, M; Erisir, Z. and Esen, A. (1998). Influence of stocking density and age on the egg characteristics in Japanese quail. *Veteriner Hekimler Dernegi Dergisi*, 5:1-7.

Punya-Kumari, B. (2007). Genetic studies on the performance of Japanese quails. Venkateswara veterinary University, Tirupathi. http://www.cibtch.org/jls.htm.

Prakash- Babu, M., Ahuja, S.D., Bisht, G.S., Gulati, D.P. and Srivastava, H.P. (1980). Genetic parameters of body weight in Japanese quail. *Indian Journal of Animal Science* 50 (4) 348-352.

PrabaKaran, R., Bacon, W.L., Martins E.N. and George, P.C. (2012). Variance components for body weight in Japanese quails (Coturnix japonica). Poultry Science 7: 23-25.

Prabakaran, R., Babu, M. and Sundararasu, V. (1991). Effect of photoperiod on the growth performance of Japanese quails. *Journal. of Veterinary Animal Science, Volume,22:9-11*

Prabakaran, R. (1990). Selection for body weight under different nutritional environments in Japanese quail. *Indian Journal of Fundamental and Applied Life Science 2231-6345*

Praharaj, N.K., Wulume, V. and Mohapatra, S. C. (1990). Studies on production and growth traits in quail (*Coturnix coturnix japonica*). *Indian, Journal Poultry Science, 25:1-7.*

Prado-Gonzlez, E.A., Ramrez-Avila, L. and Segura-Correa, J.C. (2003). Genetic parameters for body weights of Creole chickens from Southeastern Mexico using an animal model. Livestock Research for Rural Development, pages, 15-30

Qiao, M., Fletcher, D.L., Northcutt, J.K. and Smith, D.P. (2002) The Relationship Between Raw Broiler Breast Meat Color and Composition. *Poultry Science,*81:422- 427.

Qiao, M., Retcher, D.L., Smith, D.P. and Northcutt, J.K. (2001). The Effect of Broiler breast meat color on pH, moisture, water-holding capacity, and emulsification capacity. *Poultry Science, 80:676-680.*

Reddish, J.M., Nestor, K.E. and Lilburn, M.S. (2002). Effect of selection for growth on onset of sexual maturity in Random bred and growth – selected lines of Japanese quail. *Poultry Science 82: 187-191.*

Reddnesh, E., Mandal, A. and Askin, D. (2002) Introduction to Quail Production (http://www.angrin.ttri.gov.tw//apex 2003/chapter5jpquail.pdf)

Riegel, J., Rosner, F., Schmidt, R., Schuler, L. and Wicke, M. (2003). Investigation of meat quality of *m. Pectoralis* in male and female Japanese quails *(Coturnix japonica).* Proceeding of the XVIth European Symposium on the Quality of Poultry Meat, 23-26 September 2003 Saint-Brieuc, France.

Saatci, M., Harvey, W.R., Everson, D.O., Berberoglu, E. and Ulutas, Z. (2008). Genetic association between sexual maturity and live-weights in laying-type Japanese quail. *South African Journal of Animal Science, 36(2): 142–148*

Saatci, M., Omed, H. and Dewi, I.A.P. (2006). Genetic parameters from Univariate and Bivariate analysis of egg and weight traits in *Japanese quail Poult. Sci. 85: 185-190.*

Saatci, M., Omed, H. and Ap-Dewit. I. (2005). Genetic parameters from Univariate and bivariate analysis of egg and weight traits in Japanese quail. *Poultry Science, 85: 185-190.*

Saatci, M., Omed, H. and Dewi, I.A.P. (2003). genetic estimates of some productive and reproductive traits in Japanese quails. Egypt. *Poultry. Science, 30: 875-892*

Saatci, M., Dewi, I.A.P., Aksoy, R., Kirmizi-Bayrak, T. and Ulutas, Z. (2002) Estimation of genetic parameters for weekly live weight in one to one Sire and dam pedigree recorded Japanese quail.In:7oWorld congress on Genetic Applied to Livestock Production; Paris, France.Pg.1-20.

Saatci, M., Berberoglu, E. and Ulutas, Z. (2000). Genetic association between sexual maturity and live-weights in laying-type Japanese quail. *South African Journal of Animal Science 36(2): 142–148.*

Sachdev, A.K., Ahuja, S.D., Thomas, P.C. and Agarwal, S.K. (1988).Effects of egg weight and duration of storage on the weight loss, fertility and hatchability traits in Japanese quail. *Indian Journal Poultry Science, 20:19-22.*

SAS. (2004). Statistical users guide. SAS. Int., Cary, NC.USA.

Sakunlhala-Devi., Jones, S. and Prabakaran, R. (2010) Evaluation of growth traits in short term selection for different ages in Japanese quail. *Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231-6345*

Saito, K., Ida, N. and Ino, T. (1989).Genetics parameters of egg characteristics in Japanese quail. *Journal Poultry Science, 38:55-59.*

Sato,O., Qta, K. and Kawamoto, Y. (1974). effect of age and sex on serological indices of Japanese quail (Coturnix coturnix japonica). Animal Breed. Abstract, 43: (4) 4857.

Sefton, A.E. and Siegel, P.B. (1974). Inheritance of body weight in Japanese quail. *Poultry Science ,53 (4) 1597-1603*.

Selim, K., Ibrahim, S. and Ozge, Y. (2000). Effect of separate and mixed rearing according to sex on fattening performance and carcass characteristics in Japanese quail. (Coturnix coturnix japonica) *architecture Tierz, Dummerstorf,* 49 (6): 607-614.

Sengul,f., E.J. Kasan; Emami N and Maybody M.A (2007). Estimation of heritability and genetic correlations of body weight at different ages for three strains of Japanese quail.*Poultry Science, 82: 11-15*

Seker, S., Bayraktar, M. and Jones, S. (2007). Effect of parantal age and hatching egg weight of Japanese quails on hatching and chick weight. International Journal of poultry Science, 3(4):259-265.

Sezer, A., Kemal, K., Askin, G., Karsli, T. and Balcioglu, M.S. (2010). Determination of body weight and some carcass traits in Japanese quail (Coturnix coturnix japonica) of different lines. *Kafkas University Veterinary, Fat Derg. 16 (2): 277-280.*

Sezer, M. (2007). Heritability of exterior egg quality traits in Japanese quail. *Journal of Applied Biological Sciences.*1(2): 37-40

Sezer, M. Berberoglu, E. and Ulutas, Z. (2007). Genetic association between sexual maturity and live-weights in laying-type Japanese quail. *South African Journal of Animal Science* 36(2): 142–148

Sezer, H., Pinkas, D. and Otles, A. (2006). Performance of crosses of quail selected under different environments *Journal. Hered ., 64:73-76.*

Sezer, M. and Tarhan, S. (2005). Model parameters of growth curves of three meat-type lines of Japanese quail. 1. Body weight, Carcass and organ measurements. *Poultry Science, 72: 111-115, 70:1679-1688.*

Sharaf, M. M. (1994). Genetic and non genetic estimates of some reproductive and productive traits in Japanese quail. *Egypt. Poultry Science, 12: 211-231.*

Sharaf, M. and Mandour, M.A. (1994). Relationship among egg weights, egg weights loss embroyonic developments, hatch weights and chick weights in two populations of Japanese quail. *Egypt. Poultry Science, 14: 71-71-92.*

Shata, A. and Ishrak, A.E. (2001). Physiological and biochemical studies on the skeletal muscles of Japanese quail.*Indian J. of Animal Science 5:27-34*

Shebl, M.K., Rahie –EL-Dean, M. and Kosba, M.A. (1996). Selection for 6 weeks body weight in Japanese quail – Direct and correlated responses. *Egypt.Poultry Science, 16:703-723.*

Shokoohmand, M., Kashan, N.E.J. and Maybody, M.A.E. (2007). Genetic correlation of body weight in different age for three strains of Japanese quail. *Intern. Journal of Agriculture and Biology Volume, (9)6:945-947.*

Shrivastav, A.K., Johari, T.S. and Raju, M.V.L.N. (1995). Dietary protein and energy requirements of laying quails reared under different nutrient schedule during starting and growing period. *Indian .Journal of Animal Sciences., 64 (2): 173-177.*

Shrivastav, A.K and Panda, B. (1991). Distribution of fat at different locations as influenced by dietary caloric- protein ratio and energy levels in quail Broilers.*Indian Veterinary Medical Journal. 15(3):178-184.*

Singh, R.P.; Panda, B.; Ahaja, S.D.; Agarwal, S.K.; Prakash Babu, M.; Shrivastava, A.K. and Butta, O.P. (1981). Development of quails for meat and egg. Central avian Resources. Institute Izatnagar pages 42-48.

Singh, R.P. and Panda, B. (1981). Evaluation of physical quality of eggs from different lines of quail. *Indian Journal Poultry Science,21:75-77.*

Siegel, P.B. and Dunnington, E.A. (1987). Inheritance of body weight in Japanese quail. *Poultry Science, 53:1597-1603.*

Siegel, P.B. and Dunnington, E.A. (1985). Selection for growth in chickens. C R C. Crit. Rev. *Poultry Biology.,1: 1 - 24.*

Siegel, P.B. (1962). Selection for breast angle at eight weeks of age. 2. Correlated responses of feathering, BW and reproductive characteristics. *Poultry Science, 48:1009-1013.*

Snedecor, G.W. and Cochran, W.G. (1981). Statistical Method. 7th ed. The Iowa state University. Press Ames Iowa, USA.

Soller, M., Brody, T., Eitan, Y., Agursky, T. and Wexler, C. (1984). Minimum weight for onset of sexual maturity in female chickens. Heritability and phenotypic and genetic correlations with early growth rate. *Poultry Science, 63: 2103-2113*.

Song, K.T., Choi, S.H. and Oh, H.R. (2000). A comparison of egg quality of pheasant, Chukar, quail and Guinea Fowl. Institute of Agricultural Science and Technology, Chungnan National University, Taejon, Korea, 305-764.

Song, W.Y., Hurvitz, S., Talpaz, H., Bartov, I. and Plavnik, I. (1999). Characterization of growth and development of male British united turkeys. *Poultry Science, 70, 2419-2424.*

Stadelman, F.N.K., Yati,G. and Matris, V. (1977).Genetic parameters for carcass traits of Japanese quail at 56 days of age. Egyptian Poultrv Science 12, 233-247

Sundarama, G.C. (1989). The effect of dietary energy and protein on Carcass composition with a method of estimating Carcass composition. *Poultry Science, 44: 501-509.*

Syed, H., Gerken, M., Kesici, T. and Hassan, T. (1999). Effect of selection for body weight on fitness in Japanese quails. *Turkish Journal Veterinary Animal .Science,16:333-340.*

Taboada, P.A., Perez, J., Myra, J., Morfa, O. and Sachez, M.E. (1998) Effects of sex on the carcass yield and meat composition of Japanese quail (Coturnix coturnix japonica) *Revistacubana de ciencio.Aviola. 22(1): 19-24.*

Tahar, A.E. (2009). Laying performance of Japanese quails divergently selected for body weight under different rearing and lighting systems. *Ph. D. Thesis. Fac. of Veterinary Medical Alex. University Egypt.*

Tawefeuk, F.A. (2001). Studies in quails breeding using selection index for the improvement of growth and egg production in Japanese quail. http://www.unitantaegypt.org/jls.htm.

Tigali, R., Balcioglu, M.S. and Yaylak, T. (1997). Genetic and phynotypic parameters belong to different production traits of Japanse quail.I.V. Estimation of heritability belong to body weight from Ebeveyn – offspringII. Animal Symposium,9- 10 Jan.Tekirdag/ Turkey page, 274- 279.

Tish, E., Vali, N., Edriss, M.A. and Rahmani, H.R. (1997). Genetic parameters from Univariate and bivariate analysis of egg and weight traits in Japanese quail. *Poultry Science*, 2 (7): 23-26.

Thomas, M.J., George, K.C. and Nair, G.R. (1996). Selection for growth on onset of sexual maturity in Random bred and growth – selected lines of Japanese quail *Poultry Abstract, 22: 54*.

Tozluca, A. (1993). Productivity of selection according to body weight in different nutrition condition and the effect on the other production parameters in Japanese quails (*Coturnix coturnic japonica*). http://tez2.yok. gov.tr/fmi/xsL/tez/listevedetay-listsx.

Toelle, V.D., Havenstein, G.B. Nestor, K.E. and Harvey, W.R. (1991). Genetic and phenotypic relationships in Japanese quail. 1 Body weight, Carcass and organ measurements.*Poultry Science,.70: 1679-1688.*

Turedi, L. and Duzgunes, O. (1984). Genetic improvement provided for body weight of divergent selection methods in Japanese quails. Sci. Ins. Ankara University. Publication *volume. 2 number 1*.

Tservei-Gousi A.S. and Yannakopoulos, A.L. (1986). Carcass characteristics of Japanese quail at 42 days of age. *British Poultry Science, 27:123-127.*

Uluoca, K.A.N., Nacar, H. and Baylan, M. (1997). Studies on improvement of broiler quail parents. International Poultry Fair and Confrerence, YUTAV-97 Istanbul/Turkey , 14-17, May, pp 438-443.

USDA, (1983). Egg Grading Manual; USDA AMS, Agriculture Handbook 75, U.S. Government Printing office, Washington, DC.

Vali, N., Edriss, M.A. and Moshtaghi, H. (2006). Composition of egg weight between two quail strains.*Journal Poultry Science,5:398-402.*

Vali, N. Edriis, M.A. and Rahmani, H.R. (2005). Growth, feed composition and carcass composition of *Coturnix japonica*, *Coturnix ypisilophorus* and their reciprocal crosses. *Asian Journal Poultry Science, 4:132-137.*

Vali, N., Edriss, M.A. and Rahmani, H.R.(2005). Genetic parameters of growth curves of three meat-type lines of Japanese quail. 1. Body weight, Carcass and organ measurements. *International Journal of Poultry Science, 8 (9):574-582.*

Vali, N., Edriis, M.A. and Rahmani, H.R. (2000). Genetic parameters of body weight and some carcass traits in two quail strains. *International Journal of Poultry Science,* 4(5) 296- 300.

Valkova-Yorgova K., Dimitrov, D. and Danchev, S. (2000). Collagen structure and consistency of meat . Ist edition, UFT, Plovidv.

Van Laack, R.L.J.M., Liu, C.H., Smith, M.O. and Loveday, H.D. (2000). Characteristics of Pale, Soft, Exudative Broiler Breast Meat. *Poultry Science,79:1057-1061.*

Van Lengerken G., Maak, S. Wicke, M. (2012). Muscle metabolism and meat quality of pig and poultry. Veterinarija ir zootechnika, 20 (42); 82-86.

Wilson, W.O., Abbott, U.K. and Ablanalp, H. (1962). Evaluation of growth traits in short term selection for different ages in Japanese quail *British Poultry Science, 6:33-39.*

Wilson, W.O., Abbott, U.K. and Ablanaip, H. (1961) .Evaluation of Coturnix (Japonica quail) as pilot animal for poultry. *Poultry Science, 40:651-657.*

Wilhelmson, M. (1979). Breeding experiments with Japanese quail.1-The synthesis of random mated ppPopulation .Report 39.Swedish Univ. Agricultural Science.

Woodard, A.E., Abplanalp, H., Wilson, W.0. and Vohra, P. (1967). Japanese quail husbandry in the laboratory. Department of Avian Sciences, University of California,Davis,CA. Available:animalscience.ucdavis. Edu / Avian /Coturnix.pdf [Accessed 10 January 2010]

Yalcin, S., Oguz, I. and Otles, S. (1995). Carcass characteristics of quail (*Coturnix coturnix japonica*) slaughtered at different ges. *British Poultry Science,36:393-399.*

Yannakopoulos, A.L., Christaki, E. and Florou-paneri, P. (1995). Effect of age and Carcass composition on the onset of sexual maturity in quail under normal feeding regimes. *British Poultry Science, 36: 771-777*.

Zahariev, Z. and Pinkas, A. (1979) Methods for slaughter analysis and quality control of the meat. *NAIU*, Sofia.pp .32

Zelenka, D., Cherry, J.A., Nir, I. and Siegel, P.B. (1984). Body weight and composition of Japanese quail (*Coturnix coturnix japonica*) at sexual maturity. *Poultry Science,*48: 16-28.