Sudan University of Science Technology

College of Graduate Studies

Genetic Effect on Some Productive and Reproductive Traits of Black and Brown Quails Under Hot Conditions

الوراثة وأثرها علي بعض الصفات الانتاجية والتناسلية لطائر السمان الاسود والبني في البيئة الحارة

A thesis Submitted for fulfilment of the Requirements for the Degree of Doctor of philosophy in Breeding (Ph.D) (Animal production)

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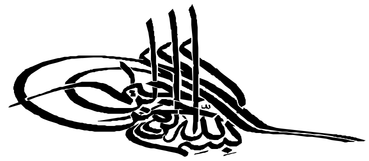
الاستهلال



وَظَلَّلْنَا عَلَيْكُمُ الْغَمَامَ وَأَنزَلْنَا عَلَيْكُمُ الْمَنَّ وَالسَّلْوَىٰ ۖ كُلُوا مِن طَيِّبَاتِ مَا رَزَقْنَاكُمْ ۖ وَمَا ظَلَمُونَا وَلَٰكِن كَانُوا أَنفُسَهُمْ يَظْلِمُونَ

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DEDICATION

To

Those who taught me a word …

To the soul my father …

To my mother …

To my wife Rabaa ...

TO MY SON Mohammed . . .

Brothers …

Sisters …

And all my friends…

With great love and gratitude …

Yassin

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I would like firstly to thank Allah for giving me knowledge, patience and support to complete this task. This study was conducted and accomplished with the help and assistance from many parties to whom I extend my sincere appreciation and thanks. At the outset I would like to express the deep gratitude which I feel for the serious and patient supervision provided to me by Professor /Mohammed Tageldin Ibrahim. I would like to extend my thanks to the University of Kassala and Also I would like to thank the College of Agriculture and Natural Resource. Also I would like to thank Dr / Ibrahim Ismail Hamid, and Gratitude's also extended to Dr / Elfadil Ahmed Adam. For their help and support and to all those who helped and encouraged me during the study period. I would like to extend my thanks to the Animal Production Department, Sudan University of Science and Technology. Sincere appreciation is also extended to ustaz/ Abubakr Sayed Ali for his help and support.

Yassin ELamin Ahmed Adam

Abstract

This study was carried out at the Animal Production Research Centre at Kuku, Khartoum North, Khartoum State, Sudan, during (April to July 2016).This study compared between Black and Brown Japanese quail (strains) Growth and production performance under Sudan conditions. Feed intake (FI), body weight (BW), body weight gain (WG), feed conversion ratio (FCR), protein efficiency ratio (PER), energy efficiency ratio (EER), age at first egg (AFE), body weight at first egg (BWFE) and liveability were determined. With the exception of liveability all other parameters were not affected by bird strain, however the Black Japanese quail had higher values than the Brown in most of the studied parameters. (FCR) for quails ranged between 2.36 to 6.99, (AFE) was determined as 9.91 week in Black strain whereas in Brown strain at 9.79 week. The overall mean of (BWFE) was 208.82 g for Black strain and 212.25 g for brown strain. Also the restricted Maximum likelihood Computer Programme was used to estimate heritability values for body weight at hatch (BWH) and at 2 (BW2), 3 (BW3), 4 (BW4), 5 (BW5), 6 (BW6), 7 (BW7) and 8 (BW8) weeks of age, age at first egg (AFE) and body weight at first egg (BWFE). The phenotypic correlations among these parameters were also determined. The results revealed that heritability of BW, were 0.60, 0.51, 0.34, 0.32, 0.23, 0.11, 0.27 and 0.06 at hatch, 2, 3, 4, 5, 6, 7 and 8 weeks respectively. These results indicate that heritability decreased as the age increased, whereas heritability estimates for AFE and BWFE was 0.53 and 0.15 respectively. Phenotypic correlations between live body weights at different ages were positive and very highly significant ($P<0.001$). These results indicated that the growth in quails can be improved by direct selection for high body weight.

ملخص الدراسة

أجريت هذه الدراسةفي مركز بحوث الإنتاج الحيواني في حلة كوكو، شمال ولاية الخرطوم السودان في الفترة من (أبريل/نيسان إلى يوليو/تموز 2016).

هذه الدراسة قارنت الأداء الإنتاجي لطائر السمان الاسود والبُني تحت ظروف السودان تم أخذ وزن العلف المستهلك الأسبوعي وزن الجسم الأسبوعي الزيادة في الوزن أسبوعياً , نسبة التحويل الغذائي, كفاءة تحويل البروتين, كفاءة تحويل الطاقة, العمر عند وضع البيضة الأولى والوزن عند البلوغ و نسبة الحيوية.باستثناء نسبة الحيوية كل القياسات الاخري كان اللون ليس له أثر معنوي (P>0.05). بصورة عامة السمان الأسود كان الأعلي في معظم قياسات الأداء موضع الدراسة. نسبه التحويل الغذائي تراوحت بين 2.36- 6.99 , متوسط العمر عند وضع البيضة الاولى كان 9.91 أسبوع في السمان الأسود أما البني كان 9.79 أسبوع ومتوسط الوزن عند البلوغ كان 208.82 جرام في طائر السمان الأسود بينما في طائر السمان البني كان 212.25 جرام. ايضاً استخدم برنامج حاسوب (المحدد لأقصى احتمالية) لتقدير المكافئي الوراثي للوزن عند الفقس وفي الأسبوع الثاني الثالث الرابع ، الخامس ، السادس ، السابع والثامن من العمر ، العمر عند وضع البيضة الأولي ووزن الجسم عند وضع البيضة الأولي. ايضًا تم تقدير إرتباط الشكل الظاهري بين هذه القياسات. اوضحت النتائج ان المكافئي الوراثي للوزن كان 0.60، 0.51، 0.34، 0.32 ، 0.23 ، 0.11 ، 0.27 و0.06 للوزن عند الفقس ، الأسبوع الثاني ، الثالث ، الرابع ، الخامس ، السادس ، السابع و الأسبوع الثامن علي التوالي. تشير هذه النتائج بأن المكافئي الوراثي يقل بتقدم العمر بينما المكافئي الوراثي للعمر عند وضع البيضة الأولي ووزن الجسم عند وضع البيضة الأولي كان 0.53 و 0.15 علي التوالي. إرتباطات الشكل الظاهري بين أوزان الجسم الحية في الأعمار المختلفة كانت إيجابية وهامة جداً (P<0.001). تشير هذه النتائج بأن النمو لطائر السمان يمكن أن يحسن بالإختيار المباشر لوزن الجسم العالي.

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List of abbreviations

abbreviations	Title
AFC	Age at first egg
BW	Body weight
BWFE	Body weight at first egg
BWG	Body weight gain
CP	Crude protein
EER	Energy efficiency ratio
FCR	Feed conversion ratio
FI	Feed intake
ME	metabolizable energy
PER	Protein efficiency ratio
rP	phenotypic correlation

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Chapter One

Introduction

World poultry industry depends mainly on chicken production for both meat and eggs. Currently there is increased production in other poultry species either for food production or genetic conservation resources goal (Hassan, 2011). Japanese quail, the smallest farmed avian species, is getting more importance for commercial egg and meat production. It has marked advantages such as fast growth, early sexual maturity, high rate of egg production, short generation interval and short incubation period. The average age at onset of laying for Japanese quail is 6-8 weeks (Sarabmeet et al., 2008). and with proper care, quail hens can lay up to 280-300 eggs in their first year. In order to establish a breeding program, it is essential to estimate genetic parameters for improving the production traits. Quail breeding offers excellent opportunity for diversification and early marketing age, hence the increasing activity in the production of Japanese quail in developing countries. Despite the small body size of Japanese quail, its meat and eggs are widely consumed and therefore can ameliorate the problem of animal protein shortage.

The advantages of Japanese quail, which have been widely used for biological and genetic studies are because of this bird has a small body size, easily handled, a large number of birds can be kept in a limited space, sexual maturation is rapidly accomplished, turnover of generations is rapid, high egg production and many offspring can be available from certain number of parents (Hassan, 2011; Hassan, 2013). Growth is the most important trait for evaluating different livestock species, especially in meat producing animals and birds. Growth traits such as body weight and body weight gain are affected by genetic and non- genetic factors and the phenomenon of growth is usually measured by observing differences in body weight recorded at different ages and/or body weight gain obtained during different growth periods (Chambers, 1993). Genetic evaluation is based on variance, covariance heritability, genetic and phenotypic correlations These parameters are also necessary to predict direct and correlated response to selection (Van Vleck 1993). Some of the estimated genetic parameters for various traits of domestics Japanese quail were reported by several workers (Kawahara and Saito, 1976, Toelle *et al*; 1991 and Minvielle *et al*. 1999, 2000). Kawahara and Saito (1976) reported the genetic parameters of different organs and body weights in the Japanese quail.

The heritability of the metric character is one of the most important properties. It expresses, the proportion of the total variance that is attributable to the average effects of genes, and this is what determines the degree of resemblance between relatives, but the most important function of the heritability in the genetic study of metric characters has not yet been mentioned, namely its predictive role, expressing the reliability of the phenotypic value as a guide to the breeding value. Only the phenotypic values of individuals can be directly measured, but it is the breeding value that determines their influence on the next generation (Falconer,1989). Several studies have been conducted on estimating direct heritability for economic traits with no attention to the existence of maternal effects in native fowl (Sang *et al*. 2006, Kamali *et al*. 2007). But only a few estimates are available for maternal genetic and permanent environmental effects (Norris and Ngambi 2006, Haunshi *et al*. 2012, Ghorbani *et al*. 2012).

The objectives of this study are:

• To estimate the genetic parameters of some traits and to estimate the genetic and phenotypic correlations among the traits in Japanese quail.

• Compare between black and brown quail performance under Sudan conditions.

• Establishing data base on the performance of Japanese quail. under Sudan conditions.

Chapter Two

Literature Review

2.1 The Japanese Quail

The Japanese quail belongs to the order Galiformes, family Phasinidae, genus Coturnix and species japonica. The scientific designation for Japanese quail is Coturnix japonica, different from the common quail “Coturnix coturnix” (Thear, 1998; Mizutani, 2003).

The first record of wild Japanese quail appeared in Japan during the eighth century and these species are found in Japan, Korea, Eastern China, Mongolia and Sakhalin as migrating birds. The plumage colour of the wild type is predominately dark cinnamon brown. However, adult female have pale breast feathers that are speckled with dark colour spots. Adult males have uniform dark rusted feathers on the breast and cheek (Mizutani, 2003). These sex differences in plumage colour appear at about the third week of age.

Japanese quail are hardy birds that thrive in small cages and are inexpensive to keep. They are affected by common poultry diseases but are fairly disease resistant. Japanese quails are usually in full egg production by 50 days of age. With proper care, hens should lay 200 eggs in their first year of lay. Life expectancy is only 2 to 2½ years. Quail eggs are a mottled brown colour and are often covered with a light blue, chalky material. Each hen appears to lay eggs with a characteristic shell pattern or colour (Randall, and Bolla.,2008).

The Japanese quail originally domesticated around the 11th century as a pet song bird, has since gained value as a food animal. Several features accounted for the utility of this bird. First, it has attained economic importance as an agricultural species producing eggs and meat that are enjoyed for their unique flavour (Kayang *et al*., 2004).

Quails are blessed with several desirable characters like fast growth, early sexual maturity, high rate of egg production, short generation interval, requirement of less floor space, short incubation period and less susceptibility to diseases. Generally quails are reared in multi-tier cages both during growing and laying periods. The convenience in handling and conservation of space and energy are major advantages with this system. However, quails are also being reared on floor equally well (Padmakumar *et al*.,2000). Japanese quail is early sexual maturity - resulting in short generation interval (3-4 generation per year), resistance to diseases and high egg production; rendered it as an excellent laboratory animal (Minvielle, 2001). It has thus been used extensively in many studies (Kayang *et al*., 2004). Japanese quail is also the smallest avian species farmed for meat and egg production (Baumgartner, 1994).

2.2 Feed efficiency:-

Feed efficiency is one of the important traits to be improved through genetic selection to realize income over feed cost. Feed conversion is a complex and highly aggregate trait which is the result of interaction of many different composite traits. Individual feed consumption records enhance selection for efficiency of growth rate and egg production in Japanese quails. Due to direct selection for increased growth rate in broilers and increased egg production in layers, improvement in feed efficiency has been achieved as a correlated response. Research findings have reported that the residual component of feed consumption i.e. individual bird difference between predicted and actual feed intake are partly heritable and respond for selection The Feed conversion ratio displays moderate to high heritability ranging from0.20 to 0.80 (Leenstra, *et al.*, 1986).

2.3 Energy and protein requirements:

The energy and protein requirements as well as the efficiency of feed utilization are still poorly documented, especially for quails. Generally, the energy and protein requirement for this category of poultry were considered to be similar to those of other poultry species, especially hens (Scholtz *et al.*, 2009). bird the most affecting factors are ambient temperature, age, physiological state (growing or laying) and metabolic body size, sex, and bird species.

Japanese quail was suggested to consume metabolizable energy per Kg BWT higher than chicken,(Shoukry *et al.*,1993a). They suggested also that the higher energy cost for egg production of Japanese quail is due to high losses of metabolizable energy from different avenues. These avenues could be the energy costs of thermoregulation where Prinzinger (1982) found that the mature Japanese quail expended about 6- 10% of its metabolic rate to adjust a new level of metabolism under temperature fluctuation conditions. Another avenue is the calorific values of fat and carbohydrates as quail lays relatively high-energy egg compared to chicken (Shoukry *et al.*,1993a). Also, Japanese quail has larger metabolic body size than the chicken which could be considered as another avenue of losing high metabolizable energy. This imp lays that Japanese quail could be different than the chicken in the energy efficiency.

The nutritional requirements of metabolizable energy (ME) and crude protein (CP) for quails have been published (Vohra and Roudybush, 1971; Sakurai, 1981; Ri *et al.*, 2005) ; however, the reported values are limited and contradictory. For instance, as the interest in the study of Japanese quail developed, the maintenance of intensive quail populations on diets containing about 28% CP was adopted (Woodard *et al*, 1965); however, later studies indicated that Coturnix can be reared on25-26% CP- diets during the first weeks(Weber and Reid, 1967) dietary content can be reduced to 20% after 3 weeks of age (Gropp and Zucker, 1968). On the other hand, dietary CP requirement of Japanese quail is relatively high and depends on body weight gain, breed, age, diet composition and environmental condition. Woodard *et al* (1965). suggested a dietary protein level of 28% for intensively- raised quails, while Whyte *et al.* (2000) suggested a dietary protein level of 18-24% for better performance. In female Japanese quail, Hashiguchi *et al* (1998). reported that feeding low protein diets lowered body weight at sexual maturity. Also, Annaka, (1994). and Marks (1993). indicated that body weight gain decreased linearly with decreasing dietary protein level in quail. Lilburn and Meyer-Miller (1990). suggested that body fat and protein depositions were increased and decreased, respectively, by decreasing dietary protein level in broiler breeder hen. Kirkpinar and Oguz (1995). stated that feeding low protein diets increased carcass fat content and decreased carcass protein content in female quail. Like other species the energy is the principal nutritional component of the diets, which determines the quail performance. The ME requirements of quails are variable depending on a number of factors including body weight gain, amino acid balance, feed efficiency, breed, house condition and stocking density (Lepore and Marks, 1971).

Sakurai (1981) obtained optimum performance with58 kcal ME/day in a smaller species. Comparing the energy utilization by quails and broiler chickens, Begin (1968) did not find any clear difference in feed: gain ratio between low or high energy diets (2200 and3400 kcal ME/ kg), concluding that quails can utilize the diets with varying energy contents similar to broilers.

Soares, *et al* (2003). evaluated five dietary crude protein levels (16,18, 20, 22 and 24%) in the rearing period of Japanese quail (Coturnix coturnix japonica) and concluded that protein levels had no effects on feed intake and feed conversion ratio. They estimated that CP requirement for rearing period of Japanese quail is 23.08%. Hyankova, *et al* (1997) also reported that Japanese quail fed 26 and 21.6% CP had a good performance from 1 to 21 and 22 to 35 d of age, respectively. Thus, their requirements decrease with age, similar to other animal species [Soares, R. *et al* 2003]. Generally the CP content in diets of growing quails ranges from 24 to 27% (Shrivastava, and Panda, 1999), (NRC1994) The response of growing quails to dietary levels of essential amino acids at different energy levels on growth and immunity were investigated by (Kaur, *et al*, 2008). They concluded that the optimum level of dietary ME is 2700 kcal kg-1 with CP 25.83% for gain and 3100 kcal kg-1 with CP 25.83% for optimum feed conversion during 0-5 weeks of age. Monica *et al*. ,(2010) reported that quails in peak laying period the corrected metabolizable energy was 955 KJ/ kg0.75, with a efficiency of metabolism of 57.4 % for gross energy and 70% for digestible energy. The efficiency of metabolizable energy utilisation on egg production was 26.6%. The efficiency of accessible protein on protein retained in eggs was 31.6%.The energy level of feed is the main factor influencing feed intake as birds will under normal circumstances eat to satisfy their energy needs (Shanaway, 1994).

2.4 Body Weight :-

Body weight is one of the most important traits for a number of reasons including its relation with other meat production traits and its' relative ease of measurement(Caron *et al*., 1990). Body weight, body conformation and yield are important traits to poultry breeders and processors (Adeniji and Ayorinde, 1990). Body weight plays an important role in determining several other economic characteristics in farm animals (Pesmen and Yanrdimen., 2008). It is an important attribute as it forms the basis for assessing growth, feed efficiency and also in making economic and market decisions in farm animals (Momoh, and Kershima, 2008). Saatci *et al*., (2006) recorded body weight of Japanese quails and found that the mean body weight was 7.6, 20.2, 43.1, 76.8, 114.5, 149.0 and178.0 g for hatch, One, two, three, four, five and six weeks of age; respectively. Shokoohmand *et al*., 2007 reported mean body weights in Japanese quail at 14, 28 and 42 days of age as 51.2 , 119.2 and 176 g; respectively. For effect of sex on body weight several studies stated that females of Japanese quails were heavier than males. Hashiguchi *et al* (1998) illustrated that, feeding low protein diets by female Japanese quail lowered body weight at sexual maturity. The effect of generation and hatch were recorded by Kumari *et al*., (2009) who represented a significant effect on body weight up to four weeks of age only. Maurice and Gerry (2005) indicated that, when Japanese quail reared under proper management males weighed about 100 to140 g, while the females were heavier and weighed from 120 to160 g.

2.5 Fertility in Japanese Quail:-

Fertility and hatchability (reproductive traits) are of the most important attributes of parent stock performance (Hunton, 1971). Fertility is defined as the interaction between maternal and paternal gametes to produce a viable zygote and can be expressed as the number of fertile eggs per bird. Hatchability on the other hand is the ratio between fertile eggs that produce viable birds and unfertilized eggs. Hatchability is the composite of the embryos' ability to survive and the maternal contribution towards embryo survival (Savegnago *et al*., 2011).

Fertility is a low heritable trait and requires a complex genetic improvement program (Wolc *et al*., 2009). Therefore, for small-scale enterprises, it is primarily of interest to perform remedial actions for the environmental effects that have an influence on the fertility.

The effects of some management methods on fertility in Japanese quail, such as, stocking density, mating ratio, rearing type investigated by Kumar *et al*. (1990), Altan and Oguz (1993) and Kirmizibayrak and Altinel (2001). Investigations indicated that grouping a single male with two to five females in colony cage will generally give high fertility. But the increase of the group size may influence bird welfare. In colony cages, aggressive behaviours are the biggest problem to rearing quails, typically numerous male birds cause stress and aggressive pecking (Ophir and Galef, 2003). Excessive male to female ratios can stress both sexes. On the contrary, cutting the proportion of males allows savings in space and feed and also results in more uniformity of progeny by increased selection intensity. When quails are kept in individual cages, a single male with one to three females is sufficient and reduces fighting among birds. Pair mating in individual cages also gives good fertility. Quail rearing in individual cages is applied more in the genetic improvement studies. The producers that apply commercial production prefer colony type cages to individual cages.

Fertility in mass-mated females continues for approximately I0 to 12 days after males are removed. Fertility remains at optimum, however, only if males are left continuously in cages with the females. Persistence of fertility appears to be slightly shorter in coturnix than in ducks and geese, about one-half that in chickens, and about one-fourth that in turkeys,(Woodard *et al.* 1973).

Sittmann and Abplanalp, (1965). found that fertility continued for approximately 11days after coturnix were placed singly in individual cages. Wentworth and Mellen, (1963), report that the mean duration of fertility of coturnix females was4.6 days with artificial insemination (single insemination) and 5.1 days with natural mating (male with female for 16 hours).

2.6 Sexual maturity:-

Sexual maturity was determined as the day of production of cloacal gland foam for males, and the day of laying the first egg for females. (Sezer, *et al*., 2006). The Japanese quail is a sexually dimorphic bird with females having a larger body size than males, unlike other poultry species. Accordingly, females require more time to reach sexual maturity than males (Reddish *et al*., 2003). (Siegel and Dunnigton, 1985),reported that Reaching sexual maturity is influenced by chronological age, body weight and body composition.

Sexual dimo phismris believed to evolve under the pressure of natural and sexual selection, which implies that genes controlling sexually dimorphic characteristics differ between males and females (Mignon-

Grasteau *et al*., 2004). Therefore, it has been suggested that genetic parameters for male and female Japanese quails should be estimated separately, 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. On the other hand, early sexual maturity promotes poultry production by increasing laying performance of the females and reducing the cost to produce males for semen production. If there is a genetic correlation between characters under selection, the overall response to selection will change according to the heritability of the traits examined, and the strength and sign of the genetic covariance among them (Jensen *et al*., 2003). In many species, members of the larger sex begin to produce gametes at an older age than members of the smaller sex. this could be expected because members of the larger sex require more time to grow to a larger size (Anderson, 1994; Charles, 1994). On the other hand, in many bird species showing sexual dimorphism, both sexes begin to produce gametes at the same age, but members of the larger sex delay final reproductive development to an older age (Stamps and Krishnana, 1997). Although early maturity is expected to cause inhibition of growth, reduction in quality or survival of offspring (Oli *et al*., 2002), such a trade- off between early sexual maturity and live weight should be stabilized evolution early, because of the importance of growth trajectories in the live weight history of species. These will also provide obvious benefits for, especially wild male quails because of the advantage of finding a mate or a territory at an early age. (Sezer *et al*., 2006) reported that males start to produce mating calls of high frequency when they are sexually mature. These mating calls may attract predators to the nesting site. Hence, early maturity of males could be important to allow the necessary time for females to develop safely without the risk of predator attacks. Early sexual maturity in Japanese quail resulting in short generation interval (3-4 generation per year), Minvielle, (2001). Bahie El- Dean *et al*., (2008) reported age at sexual maturity in Japanese quail females (days) were 42.98, 50.05 and 61.89 for early age at sexual maturity group, medium and late groups; respectively.

2.7 Age at First Egg (AFE):

In breeding research it is very important to estimate the individual birds' age at first egg. Age at first egg can be highly variable because it is affected by feeding and management practices. Early age at first egg can be advantageous because selection for it could lead to reduced generation interval, but for commercial egg production it will lead to the production of many small eggs which may not find a ready market. However if early age at first egg is accompanied by a corresponding increase in body weight then the egg size will also increase (Daikwo, *et al*.,2014). On this estimate (Daikwo, *et al*.,2014)., Sakunthaladevi et al., (2011) and Padmakumar et al., (2000) estimated the age at first egg in Japanese quail As 47.01±0.23 days, 7.67 week and 8.21 week respectively. (Bronislawa *et al*., 2008). reported that Female Japanese quails laid eggs at the age of 6 weeks. El- Full (2001) and El- Deen *et al*(2008) reported higher values of 61.22 and 50.94 days.

2.8 Egg production:

Egg production is one of the major performance parameters of laying birds. Egg production in Japanese quail is influenced by additive genetic effects and several factors such as: age at sexual maturity, weight of the bird, nutrition, the system of management and the environment. Egg production can be reported as whole record performance (by monitoring the annual production) or part-record performance (short-term production). Whole record production can be predicted from part-record egg production through the use of mathematical models and projections of the egg production curve. If significant positive genetic correlation is found between part-period egg traits and annual egg traits, early selection can be undertaken using the part-period records., average number of eggs laid per quail hen per year was 248 egg (Daikwo *et al*.,2014).

(Onyimonyi and Okeke, 2000) reported that the average egg number is about 100 to 200 eggs per bird per year. (Bronislawa *et al*., 2008). reported that Female Japanese quails laid eggs at the age of 6 weeks, and during the entire reproductive period lasting from 10 to 12 months, are able to lay about 300 eggs. Murakam and Riki, (1998). reported that Keeping Japanese quail is an economic way for producing egg, because of their early sexual maturity (laying egg after 35 days), high egg production (250–270 eggs per year), resistance to most of poultry disease and great egg production persistency on a high level (approximately 14–18 months). Japanese quail maturation happens in about 6 weeks of age and mature females are usually in full egg production by 50 days of age. With proper care, hens should lay more than 200 eggs in their first year of lay. The average egg weighs about 10–15g which is about 8% of female body weight. Feed conversion for egg production in Japanese quail is better than in laying hens. Quail hens need less than 2 kg of feed to produce 1kg of egg, while laying hens need between 1.9 to 2.5

kg of feed to make the same amount of egg. Japanese quail eggs are nearly identical in taste and nutritional quality to chicken eggs. There is an expanding market for products such as fresh or pickled quail eggs in Asian, American and some European countries (Minvielle, 2004). (Randall and Bolla 2008).who reported that Japanese quail eggs are a mottled brown colour and are often covered with a light blue, chalky material. Each hen appears to lay eggs with a characteristic shell pattern or colour. Some strains lay only white eggs. The average egg weighs about10 g, about 8% of the body weight of the quail hen. Young chicks weigh 6–7 g when hatched and are brownish with yellow stripes. The shells are very fragile, so handle the eggs with care.

2.9 Egg weight:-

The main purpose of poultry breeder farms is to produce an optimum number of fertile eggs. Both male and female individuals are important for achieving reproductive success (Altan and Oğuz, 1993). Fertility and hatchability are affected by a number of factors (Harris *et al.*, 1984; Mayes and Takeballi, 1984). Changes in many biological features due to the ageing of individual birds or flocks should be expected, as is true for all living organisms (Yannkapoulas *et al.*, 1991). One of the notable differences observed in the egg due to ageing is the increase in egg weight (North and Bell, 1991). A high level of genetic correlation exists between the live weight and egg weight of female breeders (Strong *et al.*, 1978; Marks, 1983). Heavy birds produce heavier eggs than lighter birds (Strong *et al.*, 1978; Marks, 1983; Leeson *et al.*, 1991). Egg weight is critical to the hatchability (Altan *et al.*, 1995), incubation period

(Hodgetts, 1988), chick weight (Shanawany, 1987), chick mortality during the first days (Skewes *et al*., 1988) and performance during later stages in life (Morris *et al*., 1968; Al-Murrani, 1978). Altan *et al*. (1998) reported that egg weight in a quail line selected for live weight was affected by the size of ova produced in the ovaries of females and an increase in albumen secretion, although no differences were observed in shell and albumen quality and egg production. One of the main factors affecting fertility is male to female ratio. It is generally acknowledged that fertility decreases with increasing female to male ratio (Koçak and Özkan, 2000). The average egg weight is about 10 g (Onyimonyi and Okeke, 2000). M invielle,(2004) reported that the average egg weighs about 10–15g which is about 8% of female body weight. Also (Havenstein *et al*.,1988) who reported that egg weight in Japanese quail ranged between 8.31 and 13.00g.

2.10 Egg quality:-

Egg is a biological structure intended by nature for reproduction. It protects and provides complete diets for the developing embryo and serves as the principal source of food for the first few days of the chick's life (Abanikannda and Leigh, 2007) . It has been observed in the poultry breeding that the quails (Coturnix coturnix) were benefited as much as hens both for their meat and eggs, therefore, commercial quail breeding have become widespread (Altinel *et al*., 1996).

Egg quality is the more important price contributing factor in table and hatching eggs. Therefore, the economic success of a laying flock solely depends on the total number of quality eggs produced (Monira *et al*. , 2003).

Egg quality is composed of those characteristics of an egg that affects its acceptability to consumers, it is therefore important that attention is paid to the problems of preservation and marketing of eggs to maintain the quality. Among many quality characteristics, external factors including cleanliness, freshness, egg weight and shell weight are important in consumer's acceptability of shell eggs (Song *et al*., 2000; Adeogun and Amole, 2004, Dudusola, 2010). On the other hand, interior characteristics such as yolk index, Haugh unit, and chemical composition are also important in egg product industry as the demand for liquid egg, frozen egg, egg powder and yolk oil increases (Scott and Silversides, 2001).
Egg quality is composed of those characteristics of an egg that affect its acceptability to consumers, it is therefore important that attention is paid to the problems of preservation and marketing of eggs to maintain the quality (Adeogun and Amole., 2004). Of internal egg quality characteristics, thick albumin is quite an important measure for the freshness of an egg (Toussant and Latshaw,1999).

in numerous research related to the aforementioned subjects, it has been reported that the external and internal quality traits of the eggs in both hens (Nordstrom and Ousterhout, 1982) and quails(Peebles and Marks, 1991) had significant effects on the hatchability of incubated and fertile eggs, and weight and development of the laying chicks. Moreover, some of the egg quality traits have significant and direct effects on the prices of especially commercial flocks. In the egg processing enterprises, the weight of egg shell, albumen and the yolk that form the egg as well as their rates affect the amount and price of the product (Altan *et al*. 1998).
Qualities of the breeding eggs have an overall significance for an economic breeding. Traits related with external quality of the eggs have

effects on the hatchability and development of the chicks (Khurshid *et al*.2004). External qualities of the eggs are also directly related with the amount of broken eggs, leading to serious economic problems for the breeders and the dealers (Hamilton, 1982). On the other hand, such traits of the eggs determine their value in the market by affecting the demand of consumers (Uluocak *et al*.1995). Egg composition of the domestic fowl shows high variations depend on the species, age of hens and breeding environment. Egg shell is one of the most important external characteristics of the eggs (Narushin and Romanov, 2002).It was reported that EW had a positive correlation with ST and SW (Stadelman, 1986). The percentage of shell is related to total egg weight, with larger eggs frequently having proportionately less shell. Other researchers also reported that ST had an effect on the shell stiffness (Buss, 1982). Egg specific gravity represents an easy method to test ST and has been used widely (Bennett, 1992)

At least some of the inability to resist fracture damage can be attributed to deficiencies in shell structure and shape (Hunton, 1995). It is also well known that eggs of normal shape hatch more successfully than those shaped abnormally (Narushin and Romanov, 2002).

The internal and external quality traits of eggs as well as the correlation between these traits had been studied in quails (Kul and Seker, 2004). Positive phenotypic correlation exists between egg weight and other egg biometrical traits egg length was weighty and significant correlated with egg width. The relationship between egg shape index and width is also high(Yakubu *et al*. 2008).

Egg yolk contains all of the fat in the egg, a little less than half of the protein, approximately, 55 calories, all of the egg’s fat- soluble vitamins, and a higher proportion of the egg’s water- soluble vitamins than the white, including vitamins B_6 and B_{12} folic acid, pantothenic acid and thiamine. Egg yolks are one of the few foods naturally containing vitamin D. Calcium, copper, iron, manganese, phosphorus, selenium and zinc content of the yolk are higher than those of the white. Albumen accounts for most of an egg’s liquid weight, about 66%. Majority of the egg’s niacin, riboflavin, magnesium, potassium and sodium are found in the egg white, and none of the fat. The white of a large egg contains about 17 calories (North Carolina egg Association, 2016). Vitamins A and B_2 content of chicken egg is half that content of quail egg.

Quail's eggs were easily the most powerful inhibitor of human trypsins which plays a major, role in the allergic reaction. Quail's eggs contain enzyme inhibitors other than ovomucoid (a fraction of the albumen): ovo inhibitors, glycol proteins which are also natural de- inhibitors of serine proteases and have a powerful effect on trypsins. Ovo mucoid in quail's eggs has a powerful activity on the elastase that acts in a large number of human pathologies, in particular in pulmonary emphysema and psoriasis. Quail egg is the animal product of the most balanced protein content, vitamin– mineral and enzyme able to regulate all these deficiencies, bringing back to normal any human body. Quail eggs: have a positive effect in treating kidney disease, liver and bile, ophthalmic and ENT; are valuable in the growth and development of children; revitalize the body and prolong life regardless of age; resolve anaemia, spasmophilia, nervous headaches and fatigue; are an excellent anabolic hormone and metabolic regulator with a wide action; restore body and regulates blood sugar levels in diabetes, helps a lot in cases of sexual impotence, asthma, tuberculosis, hypercholesterolemia, allergic rhinitis, allergies and eczema, and strengthens the immune system and regulate the weight and growth disorders(Takahashi *et al.*, 1994).

2.11 Incubation and hatching:-

The incubation period for quail is 17–18 days, depending on the strain and the incubation procedures. Successful hatches depend upon a good understanding of incubator controls; study the manufacturer's recommendations carefully, and save them for further reference. The two types of incubators generally available are fan-ventilated (forced-draft) and still-air machines. A forced-draft incubator is preferable, but a still-air machine works designed especially for quail. Japanese quail eggs can be incubated in any chicken egg type of incubator, although the egg trays in some machines may need modifying. Eggs should be placed large end up in the setting tray. (Randall and Bolla., 2008).

Fan-ventilated (forced-draught) incubators: Forced-draft incubators should maintain an incubating temperature of 37.5° ± 0.3°C (99.5° ±0.5°F) and a relative humidity of 60% wet bulb reading of 30° ± 0.5°C (86° ± 1.0°F) until the 14th day of incubation. Eggs should be turned every 2–4 hours to prevent embryos from sticking to the shell. On the 14th day, candle and remove any cracked eggs, infertile and dead embryos. Transfer the eggs to hatching trays and stop turning. A separate hatchery should be operated at 37.2°C (99°F) and a relative humidity of 70% wet bulb 32.2°C (90°F). If the incubator is a combined setter and hatchery it should be operated at a temperature of 37.5°C(99.5°F), but the relative humidity should be increased to 70% wet bulb 32.2°C (90°F) during hatching. The hatchery should not be opened during the hatching process. If all recommended incubation procedures have been followed, the chicks may be removed on the 17th or 18th day of incubation. (Randall and Bolla., 2008).

Still-air incubators: If a still-air incubator is used, normal incubating temperature is 38.3°C (101°F) for the first week, 38.8°C (102°F) for the second week and not exceeding 39.5°C (103°F) until hatching is completed. Temperature should be measured at the top of the eggs. Humidity should be less than 70% wet bulb 29.4°–30.5°C (85°–87°F) until the14th day of incubation; it should then be increased to 70% wet bulb 32.2°C (90°F) until hatching is completed in 17 or 18 days. (Randall and Bolla., 2008). Maintaining proper humidity in small still-air incubators can be a problem; do not open the incubator more frequently than is needed to turn the eggs, and do not leave it open for long periods of time. The eggs must be turned by hand at least three times a day, and preferably five. A pencil mark on the side of each egg may help to ensure proper turning. It may be desirable to move eggs to different locations in the incubator in case the temperature is not uniform throughout. Newly hatched chicks often tend to sprawl in hatching trays. To prevent this, crowd the eggs into a small area or fasten cheesecloth to the bottom of the hatching tray before the chicks begin to hatch. Randall and Bolla (2008).

2.12 Heritability:-

Several studies have been conducted on estimating direct heritability for economic traits with no attention to the existence of maternal effects in native fowl (Sang *et al*. 2006, Kamali *et al*. 2007). But only a few estimates are available for maternal genetic and permanent environmental effects (Norris and Ngambi 2006, Haunshi *et al*. 2012, Ghorbani *et al*.

2012). So far, no estimate is available for trends based on the best model for economic traits in these populations. Maternal effects play an important role in development of the economic traits. These effects can be caused by genetic or environmental differences between mothers or by the combination of the genetic and environmental differences (Grosso *et al*. 2010). Meyer (1997) suggested that including maternal effects in the analysis reduces the bias in the estimate of genetic variance. Maternal effects in birds are different from those of mammals, because any Maternal effect on chicks, incubated artificially, must be the residual effect of dam reflected in egg characteristics at laying (Saatci *et al*. 2006).

Estimation of genetic parameters is necessary for breeding programs, prediction of response to selection and determination of selection procedure. Since heritability depends on genetic and environment variation, it is better to estimate it in each environmental condition. Researchers have reported the heritability of body weight in Japanese quail to be between 0.30 and 0.72 at different ages. Caron *et al.* (1990) explained the importance, in the context of selection programs of genetic parameters estimates for production traits of Japanese quail. Genetic parameters of body weight in Japanese quail were calculated by Kawahara and Saito (1976) but not using Restricted Maximum Likelihood REML procedure. Although Toelle *et al*. (1991) used a REML procedure, they did not use one to one Sire and dam records for each animal. In the studies of Kocak *et al*. (1994) and Aggrey and Cheng (1994), birds from known sires and dams were used but they had an extensive pedigree file for the analyses. In addition to heritability, genetic correlations between economic traits are important for breeding programs especially for selection program. Saatci *et al*. (2003) reported heritability estimates for body weight of 0.32; 0.20; 0.21; 0.20 and 0.15 at hatch, 7, 14, 21 and 28 days old, respectively, in one to one Sire and dam pedigree recorded Japanese quail. Heritability estimates for body weight at hatch, 7, 14, 21 and 28 days old in Japanese quails were reported to be 0.38; 0.12; 0.31; 0.12 and 0.44 respectively, when Henderson methodology was used (Aggrey & Cheng, 1994). In Japanese quails, heritability values for body weight between 0.47- 0.74 at 28 days old were reported by Minvielle (1998) in a review about animal improvement for production.

2.13 Phenotypic correlation:-

The phenotypic correlation between any two quantitative traits describes the extent to which individuals above average for one trait tend to be above, below or near the average for the other traits (Pirchner, 1984). It measures the linear association between traits that is it pr edicts the deviation from the population mean in on e trait of an individual as a function of its deviation from the population mean of other when both traits are measured in their respective phenotypic standard deviation units. Gihan and Ensaf, (2012) reported that the knowledge of correlations among productive traits is essential for the construction of selection indices designed to maximize the rate of genetic improvement.

The phenotypic correlation (rP) measures the degree to which two traits co vary among individuals in the population. If two traits co vary, it means that variance in one is related to variance in the other. The phenotypic correlation is made up of two components: the genetic and environmental correlations. The genetic correlation estimates the degree to which two traits are affected by the same genes (pleiotropy) or pairs of genes (Conner, 2002).

Chapter Three

Materials and Methods

3:1 Study area:

This study was carried out at the Animal Production Research Centre at Kuku, Khartoum North, Khartoum State, Sudan, during (April - July 2016). Minimum and maximum temperatures outside the poultry unit were 26.1˚C and 40˚C respectively and relative humidity was low in the range of twenties.

3:2 Birds and diets:

Eighty (Black44 males and females and Brown 36 males and females) of quails which were developed previously by selection for body weight and used in this study. One male and one female parents were kept together in individual cages .50×.50 m^2, parents were 24 weeks old. Eggs were collected separately from individual cages and eggs of each parents were placed separately and then transferred to the incubator. The incubation period for quails is 17-18 days, at incubating temperature of 37.5° ± 0.3°C (99.5° ±0.5°F) and relative humidity of 60% wet bulb reading of 30° ± 0.5°C (86° ± 1.0°F) until the 14^{th} day of incubation. Eggs were turned every 2 hours to prevent embryos from sticking to the shell until the 14^{th} day after that the eggs were transferred to hatching trays and turning was stopped. Hatchery was operated at 37.2°C (99°F) and relative humidity of 70% wet bulb 32.2°C (90°F) as was mentioned by Randall and Bolla.(2008).The chicks were removed on the 17^{th} or 18^{th} day of incubation. After hatching, each offspring was identified manually for each cage. All offspring were raised in battery brooders until 3 weeks of age and then were transferred to growing cages until10 weeks of age. Feed and water were supplied adlibitum and light provided for 24 hours.

A total of 123 offspring comprising 22 full-sibs families of Japanese quails were used in this study. The birds were fed on two (starter and grower) balanced rations according to (NRC.1994). Starter ration (26% crude protein and 2914 kcal ME/kg) was provided from day one up to week six (Hamid and Yassin, 2015). and the grower ration (22% crude protein and 2835 kcal ME/kg) was provided from week seven up to week ten as recommended for quail under Sudan conditions by Hamed *et al*, 2016. The Ingredients(%) and chemical composition of the experimental diets are shown in Table1below.

Table (1):

Ingredients(%) and chemical and calculated composition of the experimental diet

Ingredients	Diets	
	Starter and grower	breeder
Sorghum	57.00	65.00
Groundnut cake	34.20	23.00
Wheat bran	2.50	1.00
Concentrate	5.00	5.00
Calcium carbonate	0.9	5.25
Dicalcium phosphate (DCP)	0.00	0.20
Salt	0.25	0.25
Methionine	0.10	0.10
Lysine	0.10	0.10
Antifunaltoxins	0.10	0.10
Total	100.00	100.00
Calculated composition: crude protein	26.00	22.00
Ether Extract	3.5	3.6
Crude fibber	4.2	4.3
Calcium	1.1	2.5
Available phosphorous	0.59	0.56
Lysine	1.3	1.00
Methionine	0.52	0.48
ME (kcal/kg)	2914	2835

Source (Hamid and Yassin, 2015) (Accepted for publication J. of Sci. and Tech. (Sudan University Since and Technology).

Hamed *et al*, (2016).

3:3 Housing and management:

The study was carried out in an open sided house. The dimensions of each cage were .50×.50 m^2. The poultry house was dry cleaned washed and disinfected before arrival of birds. Feeders and drinkers were routinely cleaned, washed and disinfected at the beginning of the experiment. Wood shavings were used as litter. Drinkers were daily cleaned and filled with fresh water, birds were offered feed and water ad libitum throughout the experimental period. and light was provided for 24 hours. As no information about vaccination program for quails in the Sudan is available, hence no vaccination was done.

3:4 Measurements:

The hatched chick weight was taken at the hatchery before transferred to the farm. The weekly live body weight and the remaining feed per replicate was recorded using sensitive electronic balance. Consequently, weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) were calculated.

Feed conversion ratio (FCR) was calculated by dividing the amount of feed consumed on body weight gain (g feed/ g gain).

Protein efficiency ratio (PER): = weight gain/ protein intake according to (Kamran *et al*, 2008).

Energy efficiency ratio (EER): = (weight gain×100)/energy intake according to (Kamran *et al*,2008).

Liveability %: was determined by calculating the difference in birds number at the initiation and termination of each week until week 10.

The heritability was calculated from following equations (Falconer, 1989; Düzgüneş et al, 1987).

$$h^2 = 2 \frac{\text{total genetic variance}}{\text{total phenotypic variance}}$$

Statistical analysis:

A completely randomized design was used in the experiment. The data were subjected to analysis of independent samples T-test using SPSS software program, version 16 (2007). The means and standard error were calculated. Heritability was estimated by variance components using restricted maximum likelihood. Pearson’s correlation was used in estimating the association between the studied parameters. The SPSS software program, version 16 (2007) was used for data analysis.

Chapter Four

Results

4.1 Performance parameters:-

4.1.1 Feed intake (FI):

The mean values of feed intake of Japanese quail are shown in Table 2. The result showed that feed intake of Japanese quail was not significantly affected by strains. The overall mean feed intake during experiment ranged between 18.12g for week one to 83.44g for week six in Black strain whereas in Brown strain ranges between 17.60g for week one to 81.05g for week six. Generally Black strain consumed higher feed intake but not significant than brown strain.

4.1.2 Body weight (BW):-

The mean values of body weight of Japanese quail (Table 3) revealed no significant different between the two quail strain. Moreover the live body weight ranged between 14.14 to 208.71g and 13.47 to 212.48g in Black strain and Brown strain respectively. However the brown Japanese quail had higher values than the Black in most of the growth weeks.

4.1.3 Body Weight gain (BWG):

Body weight gain in this study (Table 4) was not affected by Japanese quail strain. The weekly gain in body weight (g) increased up to 5th week, and declined thereafter (Figure 3,4). Furthermore the mean values of weight gain ranged from 7.42g for the first week to 32.44 g for the fifth week in Black strain and ranged from 6.83g for the first week to 31.70g for the fifth week in Brown strain. Commonly Brown strain birds showed higher weight gain over the values of Black strain in most of the weeks.

Table(2):

Effect of Japanese quail strain on feed intake

Period/weeks	n	Feed intake (g/bird/week) Black Mean ± SD	n	Brown Mean ± SD	P. value
Week1	93	18.12± 0.51	30	17.60±0.32	0.389
Week2	93	35.27±0.56	30	36.47±1.05	0.302
Week3	92	56.45±0.41	30	54.62±0.94	0.082
Week4	90	67.27±1.00	30	65.41±1.84	0.361
Week5	90	76.61±1.10	30	74.87±2.22	0.453
Week6	88	81.34±0.87	28	78.31±2.22	0.213
Week7	84	82.77±0.82	28	79.65±2.20	0.192
Week8	80	82.79±0.83	26	81.17±2.14	0.485
Week9	78	82.58±0.79	26	81.05±2.08	0.497
Week10	75	83.44±0.79	25	81.26±2.14	0.348

n = number of birds

SD = standard deviation

Table (3):

Effect of strain on live body weight for Black and Brown Japanese quail

	Body weight (g/bird/week)				
	n	Black	n	Brown	P. value
		Mean ± SD		Mean ± SD	
Egg weight	93	11.39 ±0.13	30	10.53±0.19	0.000
Hatch weight	93	6.72 ± 0.70	30	6.63 ± 1.11	0.572
Week1	93	14.14± 0.35	30	13.47±0.41	0.220
Week2	93	28.98 ±0.82	30	30.57±1.23	0.326
Week3	92	55.62±1.39	30	57.50±2.47	0.506
Week4	90	76.37±1.50	30	78.70±2.72	0.443
Week5	90	108.81±2.03	30	110.40± 3.85	0.703
Week6	88	136.61± 2.32	28	136.43± 4.35	0.969
Week7	84	157.06±2.39	28	157.93±4.46	0.859
Week8	80	178.88±2.34	26	176.43±4.74	0.619
Week9	78	194.90±2.44	26	194.23 ±4.47	0.893
Week10	75	208.82±2.72	25	212.25 ±5.03	0.749

n = number of birds

SD = standard deviation

Table (4):

Effect of strain on weight gain for Black and Brown Japanese quail

	weight gain (g/bird/week)				P. value
	n	Black Mean ± SD	n	Brown Mean ± SD	
Week1	93	7.42±0.32	30	6.83±0.41	0.26
Week2	93	14.84±0.66	30	17.10±1.11	0.09
Week3	92	26.53±0.85	30	26.93±1.71	0.82
Week4	90	29.74±0.90	30	30.20±1.81	0.81
Week5	90	32.44±1.22	30	31.70±1.85	0.75
Week6	88	27.28±0.74	28	26.89±1.56	0.81
Week7	84	19.50 ±0.86	28	21.50±1.53	0.26
Week8	80	20.24±0.84	26	18.76±1.34	0.38
Week9	78	16.40±0.85	26	17.81±1.50	0.41
Week10	75	14.64±0.75	25	17.78±2.41	0.10

n = number of birds

SD = standard deviation

4.1.4 Feed conversion ratio (FCR):

The mean values for feed conversion ratio up to 10 weeks age are shown in Table 5. The overall mean of feed conversion ratio was ranged from 2.39 to 8.54 for Black strain and 2.36 to 6.55 for Brown strain.

4.1.5 Protein efficiency ratio (PER) and energy efficiency ratio (EER):

The results of protein efficiency ratio (PER) and energy efficiency ratio (EER) are presented and it was observed that quail strain had no significant effect on PER and EER, high protein efficiency ratio was observed in week 1 to week 6 it ranged between 1.42 to 2.15 and1.55 to 2.24 for Black and Brown strain respectively. while lowest protein efficiency ratio observed in week 7 to 10 for Black and Brown strain ranged between 0.79 to1.12 and 1.00 to 1.22 respectively. As well high energy efficiency ratio was observed in week 1 to week 6 for Black and Brown strain it ranged between 2.64 to 3.99 and 2.87 to 4.15 respectively. while lowest EER observed in week 7 to 10 for Black and Brown strain ranged between1.47 to 2.07 and 1.85 to 2.28 respectively.

4.1.6 Age at first egg (AFE) and Body weight at first egg (BWFE):

The results of (AFE) and (BWFE) are shown in Table 8. Age at first egg was determined as 9.91 week in Black strain and 9.79 week in Brown strain.

Table (5):

Effect of strain on feed conversion ratio for Black and Brown Japanese quail

	Feed conversion ratio				P. value
	n	Black	n	Brown	
		Mean ± SD		Mean ± SD	
Week1	93	2.68±0.09	30	3.15±0.46	0.32
Week2	93	2.86±0.15	30	2.39±0.15	0.03
Week3	93	2.42±0.12	30	2.36±0.22	0.79
Week4	90	4.12±0.29	30	5.36±0.28	0.35
Week5	90	2.86±0.19	30	2.74±0.25	0.75
Week6	88	3.22±0.12	28	3.60±0.63	0.37
Week7	84	6.42±1.10	28	4.36±0.41	0.27
Week8	80	5.01±0.41	26	5.03±0.49	0.96
Week9	78	6.99±0.71	26	5.87±0.80	0.40
Week10	75	8.54±1.26	25	6.55±5.35	0.28

n = number of birds

SD = standard deviation

Table 6:

Effect of strain on protein efficiency ratio for Black and Brown Japanese quail

	Protein efficiency ratio				P. value
	n	Black	n	Brown	
		Mean ± SD		Mean ± SD	
Week1	93	1.85±0.05	30	1.76±0.10	0.490
Week2	93	1.90±0.08	30	2.14±0.14	0.125
Week3	93	2.15±0.07	30	2.24±0.14	0.559
Week4	90	1.42±0.06	30	1.55±1.14	0.424
Week5	90	1.98±0.08	30	1.94±0.12	0.799
Week6	88	1.55±0.05	28	1.48±0.12	0.520
Week7	84	1.08±0.05	28	1.15±0.10	0.529
Week8	80	1.05±0.05	26	0.96±0.10	0.391
Week9	78	0.87±0.05	26	0.95±0.10	0.447
Week10	75	0.75±0.05	25	0.96±0.14	0.180

n = number of birds

SD = standard deviation

Table 7:

Effect of strain on energy efficiency ratio for Black and Brown Japanese quail

	Energy efficiency ratio				
	n	Black	n	Brown	P. value
		Mean ± SD		Mean ± SD	
Week1	93	3.41±0.10	30	3.27±0.19	0.490
Week2	93	3.52±0.14	30	3.97±0.26	0.125
Week3	93	3.99±0.13	30	4.15±0.25	0.559
Week4	90	2.64±0.12	30	2.87±0.26	0.424
Week5	90	3.68±0.16	30	3.60±0.22	0.799
Week6	88	2.81±0.10	28	2.74±0.22	0.762
Week7	84	1.88±0.10	28	2.13±0.18	0.216
Week8	80	1.82±0.12	26	1.78±0.18	0.848
Week9	78	1.48±0.10	26	1.76±0.19	0.183
Week10	75	1.24±0.09	25	1.59±0.26	0.212

n = number of birds

SD = standard deviation

Table 8:

Effect of Black and Brown Japanese quail strain on Age at first egg and Body weight at first egg

	Bird strain				
	n	Black	n	Brown	P. value
		Mean ± SD		Mean ± SD	
Age at first egg (week)	67	9.91 ± 0.15	24	9.79± 0.19	0.662
Body weight at first egg(g)	67	208.82±2.96	24	212.25 ±5.72	0.570

n = number of birds

SD = standard deviation

4.1.7 Liveability %:

The mean liveability of percentage of Japanese quails was recorded in Table 9. The strain had significant effect ($P<0.01$) on the liveability. The highest liveability value (100.00 %) was observed in Brown strain in weeks 1 to 5, while Black strain liveability % ranged from 75.49 to 100 in the whole experimental period.

4.2 Genetic parameters:-

4.2.1 Heritability estimates:-

4.2.1.1 Live body weight:-

The estimation of the sire and dam variance ($\sigma^2_{\text{sire and dam}}$) and SE ($\sigma^2_{\text{error}}$) of the live body weight were shown in table (10). The heritability of live body weight showed gradual decrease from hatch weight until week 6 then it increased in week 7 and then it decrease in week 8 (Figure 5).

4.2.1.2 Age and weight at first egg:-

The estimation of sir and dam variance ($\sigma^2_{\text{sire and dam}}$) and SE ($\sigma^2_{\text{error}}$) were 7.546, 20.955and 26.264, 320.962 respectively of both age and weight at first egg (Table 11), heritability of age at first egg was found to be moderate as (0.53) and low (0.15) for weight at first egg.

4.2.2 Phenotypic correlation:-

With the exception of hatch weight the phenotypic correlation for body weight of Japanese quails at different weeks revealed significant (P<0.01) increasing in correlation coefficients by increasing in age, the correlation coefficients ranged from 0.331 between hatch ,week 6 and 0.848 between week 7, week 8.

Table (9):

liveability of Black and Brown strains of Japanese quail

	Liveability %				P. value
	n	Black Mean ± SD	n	Brown Mean ± SD	
Week1	93	100.00±0.00	30	100.00±0.00	0.422
Week2	93	100.00±0.00	30	100.00±0.00	0.440
Week3	93	100.00±0.00	30	100.00±0.00	0.060
Week4	90	96.77 ±1.18	30	100.00±0.00	0.005
Week5	90	96.77 ±1.18	30	100.00±0.00	0.005
Week6	88	92.86±1.91	28	93.33 ± 2.48	0.898
Week7	84	85.0 4± 3.04	28	93.33 ± 2.48	0.045
Week8	80	82.89 ± 3.17	26	86.67 ± 3.03	0.035
Week9	78	78.132±3.44	26	80.00 ± 3.87	0.606

Week10	73	75.49± 4.04	23	76.67± 3.87	0.532

n = number of birds

SD = standard deviation

Table (10):

The estimation of sir and dam variance ($\sigma^2_{sire\ and\ dam}$) , ($\sigma^2_{error}$) and heritability of body weight in Japanese quail

weeks	$\sigma^2_{sire\ and\ dam}$	σ^2_{error}	heritability
Hatch weight	0.154	0.357	0.603
Week2	13.064	38.504	0.507
Week3	25.536	123.224	0.343
Week4	26.934	143.917	0.315
Week5	29.605	223.886	0.234
Week6	14.978	264.648	0.107
Week7	50.783	326.797	0.269
Week8	8.462	279.618	0.059

Table (11):

The estimation of sir and dam variance ($\sigma^2_{sire\ and\ dam}$) , ($\sigma^2_{error}$) and heritability of age and weight at first egg in Japanese quail

Trait	$\sigma^2_{sire\ and\ dam}$	σ^2_{error}	heritability
Age at first egg	7.546	20.955	0.529
Weight at first egg	26.264	320.962	0.151

Table(12):

Phenotypic correlation for body weight of Japanese quails at different ages and AFE

weight	Hatch weight	wt2	wt3	wt4	wt5	wt6	wt7	wt8	AFE
Hatch weight	1	0.488**	0.414**	0.364**	0.337**	0.331**	0.374**	0.386**	0.021
Weight week2		1	0.773**	0.716**	0.559**	0.522**	0.585**	0.521**	-0.082
Weight week3			1	0.721**	0.722**	0.674**	0.660**	0.593**	-0.150
Weight week4				1	0.744**	0.695**	0.603**	0.504**	-0.198*
Weight week5					1	0.835**	0.704**	0.667**	-0.277**
Weight week6						1	0.791**	0.704**	-0.201*
Weight week7							1	0.848**	-0.257**
Weight week8								1	-0.170

** Significant at (P< 0.01)
* Significant at (P< 0.05)
AFE Age at first egg

The equations generated using the linear model:-

1/ simple regression: Y = a + b X

Y = weight of quail (g)

a = intercept, (constant).

b = slope, the regression coefficient the change in Y per unit change in X.

X = age of quail. (week)

body weight (g) = -27.260 +22.141× age (week) (r^2 = 0.94)

observation:

1- Each hen appears to lay eggs with a characteristic shell pattern or colour, appendix(1).for each strain(Black and Brown Quails).
2- Males have a cloacal gland, a bulbous structure on the upper edge of the vent that secretes a white, foamy material unique gland can be used to assess the reproductive fitness of the males, when males are removed or kept without female this white, foamy material missing.
3- The colour of bird had not significant effect on performance the two strains of japanese quail.

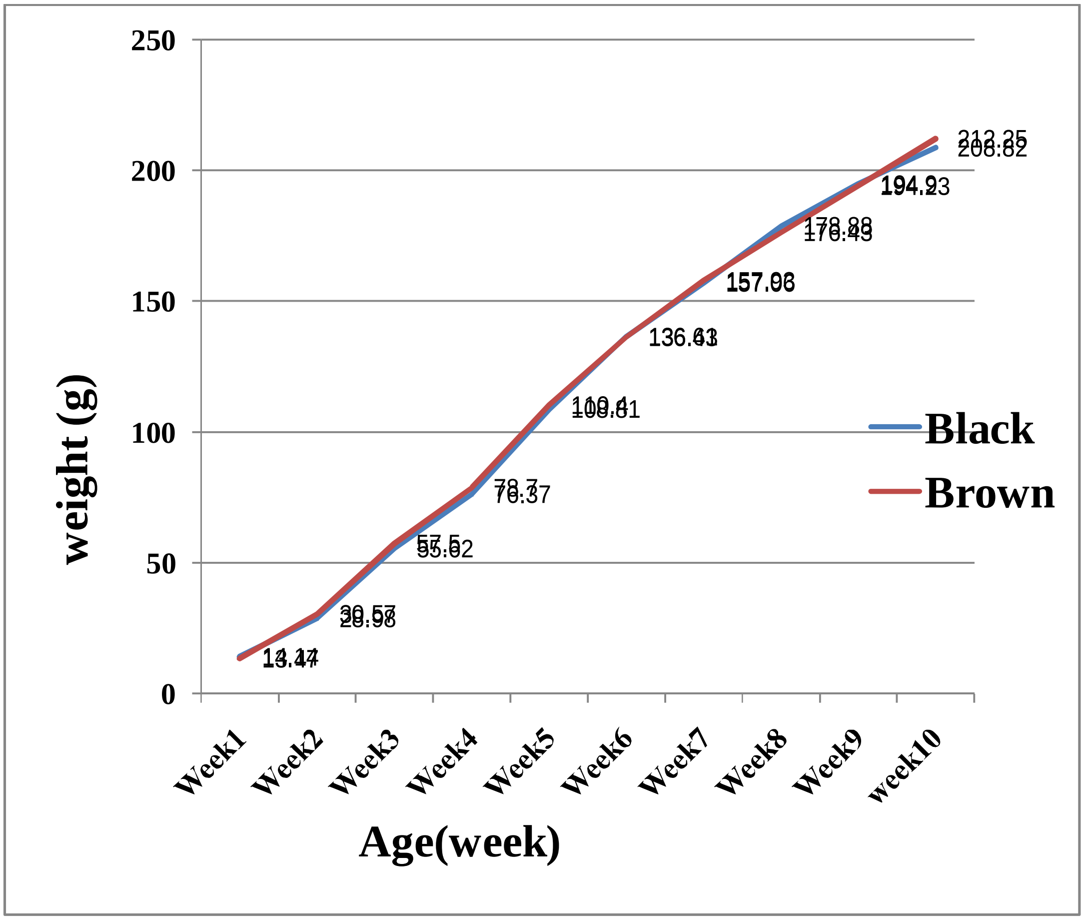

Figure (1): Live body weight at different ages for Black and Brown strain of japanese quail

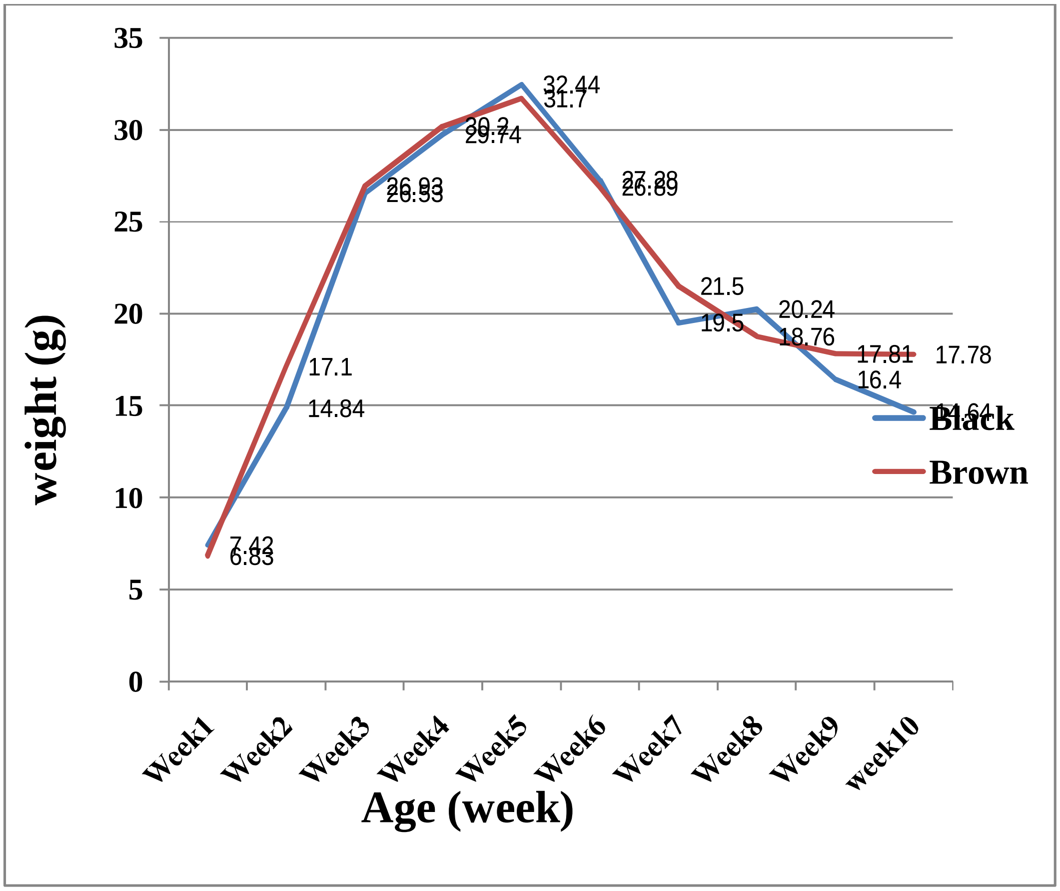

Figure (2): weight gain at different ages for Black and Brown strain of japanese quail

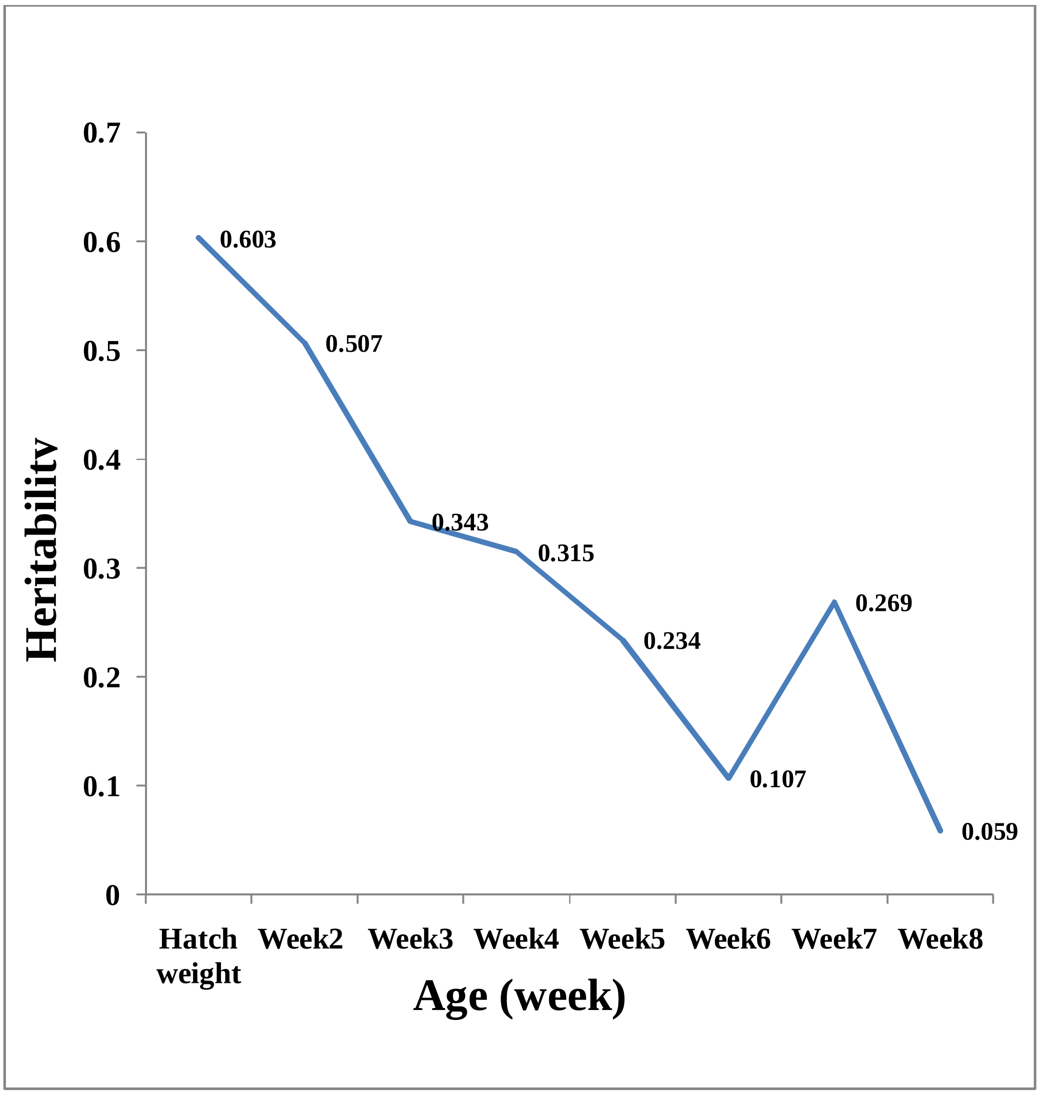

Figure (3): heritability estimations for body weights at different ages for japanese quail

Chapter five

Discussion

The result showed that feed intake of Japanese quail was not significantly affected by strain. average weekly feed intake was 55.84g in Black strain from 1-6 weeks of age whereas in Brown strain was 54.55g. This result agree with Hamed *et al*., (2016) who found that average weekly feed intake ranged between 57 to 63g from 1to 6 weeks of age. This result disagree with those of Tuleun *et al*., (2009) who found that average weekly feed intake ranged between 44.94 to 49.20g for 1to 6 weeks of age it might be due to different in season. While Sakunthaladevi, *et al*., (2012) reported that Black strain birds consume more feed and gain higher body weight gain from 1-6 weeks of age as compared to Brown strain.

Body weight is one of the most important traits for a number of reasons including its relation with other meat production traits and its' relative ease of measurement (Caron *et al*., 1990). The mean values of body weight of Japanese quail in this study revealed there was no significance different between the two quail strain, typical trend for body weight for both strains. This result could be due to the similarity in feed intake of both Black and Brown quail strain. The body weight at hatch obtained in this study is in agreement with Abdel- Fattah (2006) and Abdel- Tawab (2006) who reported values that ranged between 6.0 and 9.3g. The mean values of body weight of Japanese quail in this study differed from those of Rahman *et al.* (2010) and Islam *et al.* (2011) who reported that body weight at different ages were significantly influenced by different types of colour mutants or varieties of quails.

Body weight gain in this result (Table 4) was not affected by Japanese quail strain. result could be due to the likeness in feed intake and genetics of both quail strains. Furthermore the mean values of weight gain ranged from 7.42 to 32.44 g/week and 6.83 to 31.70g/week from 1 to 5 weeks of Black and Brown strain respectively. This results were disagreed with those of Ozsoy and Orhan (2011) who reported that weekly body weight gain from 1 to 5 weeks ranged between 15.3 to 40.5g it might be attributed to different in environmental condition. As well Sakunthaladevi *et al.*, (2012) reported that weekly body weight gain from 1 to 4 weeks of age was more in Black strain as compared to Brown strain, whereas during the 5^{th} and 6^{th} week, the Brown strain birds showed higher weight gain over the values of Black strain. The result was slightly above with those of Tuleun *et al.*, (2009) who found that average weekly body weight gain ranged between 11.05 to 12.46g from one to six weeks of age. The declining increase in body weight gain after the fifth week due to early puberty age and the ova and sperms formation needs energy and protein.

Feed conversion ratio (FCR) is one of the key performance indicators for livestock production. The average weekly feed conversion ratio in this study in six weeks of age ranged from 3.03 to 3.27 for Black and Brown strain respectively. This results somewhat similar to those reported by Tuleun *et al.*, (2009) and Sakunthaladevi, *et al.*, (2012) they were found that average weekly feed conversion ratio for six weeks of age ranged from 4.35 to 5.09 and 1.70 to 6.30 respectively. The weekly feed conversion ratio increased after week six that due to declined in weight gain. The results in this study was lower than these reported by karaman *et al*., (2009). who found that FCR ranged from 3.69 – 4.00 in different diets. As well as Erener *et al*., (2002). reported that FCR ranged from 5.02 – 5.44. Generally, several studies reported that feed conversion ratio for quails was poor compared to broilers chicken. (Emiola *et al*., 2003; Weber and Reid, 1967; Haruna *et al*., 1997; and Sobamiwa and Longe, 1998).

The results of protein efficiency ratio (PER) and energy efficiency ratio (EER) are presented in Table 3 and it was observed that quail strain had no significant effect on PER and EER, high protein efficiency ratio was observed in week 1 to week 6, while lowest protein efficiency ratio observed in week 7 to 10. This might be due to change in crude protein level in both used diets and age of quail. This finding was in line with those of Genchev *et al.* (2005) and Tuleun *et al.* (2008) who showed that the PER were changed with age of quails. This result also it was similar with those of Erener *et al.* (2002) who found that PER ranged from 1.20-1.29. Like other species the energy is the principal nutritional component of the diets, which determines the quail performance, high energy efficiency ratio was observed in week 1 to week 6 for black and brown strain it ranged between 2.64 to 3.99 and 2.87 to 4.15 respectively. while lowest EER observed in week 7 to 10 for black and brown strain ranged between1.47 to 2.07 and 1.85 to 2.28 respectively.

Early age at first egg can be advantageous because selection for it could lead to reduced generation interval. The result was not similar to Sakunthaladevi *et al*., (2011) , Padmakumar *et al*., (2000) and Momoh *et al*.(2014). who found that the ages at first egg was 7.76 week a, 8.21 and

7.78 week respectively. as well Bahie El- Dean *et al.*,(2008) reported ages at first egg in Japanese quail females (weeks) were 6.14, 7.15 and 8.84 for early age at first egg group, medium and late groups; respectively. Daikwo *et al*.,(2014). reported that ages at first egg was 47 day.

The overall mean of body weight at first egg observed for Black strain was 208.82 g and 212.25 g in Brown strain. The weight at first egg was not affected by quail strain, this result disagreed with those of Sakunthaladevi *et al.*, (2011), and Momoh *et al.*(2014). in Japanese quails. Lotfi *et al.* (2012). who reported that the average of AFE and BWFE were 48 days and244 g, respectively, this result point out that the high body weight in early age lead to early age at first egg.

The highest liveability value (100.00 %) was observed in Brown strain in weeks 1 to 5, Shamna (2008) reported a similar mean liveability % ranging from 97.90 to 100.00 from 1 to 6 week of age in Japanese quails. However Black strain liveability % ranged from 75.49 to 96.77 in the whole experimental period.

The heritability estimations for body weights at hatch, two, three, four five and six weeks of age were 0.60, 0.51, 0.34, 0.32, 0.23, and 0.11 respectively, heritability estimate reduced with age. There is great influence of the environment effect on BWH. This effect increases when age increases. This result was similar with the findings of Momoh *et al.* (2014) who reported that heritability values for body weight decreased with the age of the bird and were found estimates of heritability of body weight was high at hatch, week 1 and week 2, moderate at weeks 3 and 4 and low at the 5th and 6th week, respectively. As well this result agreed with the estimates reported by Bahie El– Dean, (2008). who reported that heritability estimate for body weight in Japanese quails from sire components for hatch, two, four and six weeks of age were 0.62, 0.39, 0.36 and 0.29; respectively. Also this result was similar to the estimates reported by Saatci *et al*., (2003) who reported that heritability estimates for body weight in Japanese quails were 0.51, 0.32, 0.20, 0.21, 0.20, 0.15, and 0.14 for hatch, first, second, third, fourth, fifth, and sixth week of age; respectively, in one to one sire and dam. The obtained heritability of body weight at hatch was 0.60. This result disagreed with the findings of Daikwo (2011), Momoh *et al.* (2014) and Adeogun and Adeoye (2004), who reported higher heritability values at hatch 0.91, 0.82 and 1.08 respectively. The result also disagreed with El-Full *et al*. (2001), Vali *et al*. (2005) and Resende *et al*. (2005), who found 0.26, 0.26 and 0.33, respectively, which were lower compared to the obtained value. Moreover, Gökhan *et al*. (2016) reported that heritability estimations of body weight of Japanese quail in the 3rd, 4th, and 5th week of age were 0.30, 0.70 and 0.30 respectively. Also Magda *et al*. (2010) reported that heritability estimate for body weight in Japanese quails for hatch, two, four and six weeks of age ranged from(0.74 to 0.82), (0.24 to 0.90), (0.16 to0.30) and (0.10 to 0.21) for the three generations respectively. As well Minvielle *et al* (1999) who reviewed reports from several studies stated that the heritability estimations for body weights at 4 and 8 weeks of ages increased with age and ranged between 0.47 to 0.74. Resende *et al* (2005) reported that heritability estimate were 0.33; 0.35; 0.36; 0.43 and 0.47 at hatch, 7, 14, 21 and 28 days old, respectively, and were indicated that heritability increased with age. Toelle *et al*. (1991) reported that heritability estimations from sire, dam and sire plus dam components unadjusted for body weight were 0.49, 0.70 and 0.59 respectively. However several studies stated that the heritability increased with age and several studies reported that the heritability estimate was reduced with age, It seems that differences in heritability estimates might be attributed to method of estimation, strain, environmental effects and sampling error due to small data set or sample size. The definition of the correct model is important, because more complex models, are required for larger effort for solution. The low heritability estimates of body weight at week six imply that response to selection for body weight at the 6th week could be slow while the moderate to high heritability estimates obtained for body weight at hatch age, two, four, five and seven weeks indicates that response to selection for body weight at these ages could be rapid. This result suggests that live body weight can be improved through individual selection. On the basis of heritability estimates obtained for body weights at various ages, selection for body weight can start within the hatch, two weeks of age due to high body weight heritability at this age. The low to moderate heritability of body weight at grown-up ages may point to that environmental effects were more important in influencing body weight at these ages than additive genetic effects.

Age at first egg and weight at first egg are considered as criterions for sexual maturity in birds and refer to age and weight at first egg, respectively. AFE and BWFE together are the most important economic traits in laying birds. Genetic improvement for egg production would increase the production efficiency and profitability of Japanese quail.

Age at first egg can be highly variable because it is affected by feeding and management practices. Early age at first egg can be advantageous because selection for it could lead to reduced generation interval. The moderate heritability estimate (h^2=0.53) of age at first egg reported in this study is slightly above with the findings of Daikwo (2014) and Momoh *et al*. (2014).who reported heritability estimates for age at first egg 0.31±0.08 and 0.48±0.17 respectively. This result disagree with the estimates reported by Sezer *et al*. (2006) who reported heritability estimates for age at first egg in Japanese quails was 0.24± 0.118 and 0.33± 0.136 for male and female respectively. As well this result disagreed with the findings of Abdel-Mounsef (2005) and El-Full (2001) who reported heritability estimates for age at first egg in Japanese quails at .33, 0.18 and 0.27. Moreover, Sakunthaladevi, *et al*. (2012) reported that heritability estimates for age at first egg in Japanese quails was 0.12+0.02 and 0.09+0.03 in Black and Brown females respectively. which were lower compared to the obtained value. Shebl *et al*., 1996 found that heritability estimates for age at first egg in Japanese quails was 0.28 from sire component, as well as Magda *et al*. (2010). who reported heritability estimates of age at first egg ranged from low to high (0.07 to 0.44) for the three generations. On the other hand the negative significant phenotypic correlation between age at first egg and body weight at different ages shown in this study. This result agreed with Sezer *et al.* (2006) who reported that phenotypic correlations between age at first egg and weekly live weight of females were negative. This means the early age at first egg is accompanied by a corresponding increase in body weight.

The consequent values for body weight at first egg disagreed with Lotfi *et al*. (2012). who reported that heritability estimate for weight at first egg at 0.36. This result agreed with that range of 0.17 to 0.78 reported by Strong *et al*. (1978) and Farahat (1998). On the other hand Momoh *et al*. (2014). reported 0.38 for the same trait. Heritability estimate of body weight at first egg disagreed with the range of 0.25to 0.59 reported by Shamma (1981). The moderate heritability estimates recorded for age at first egg suggest that improvement using selection procedure can be used.

Phenotypic correlation among body weights at different ages in Japanese quail are presented in Table4. The phenotypic correlation between any two quantitative traits describes the extent to which individuals above average for one trait tend to be above, below or near the average for the other traits (Pirchner, 1984).

Generally, phenotypic correlation between body weights at all ages in this study were positive and ranged from medium to very high significant (P<0.001). The phenotypic correlation estimates between body weights at different ages were similar in magnitude and direction and increasing in correlation coefficients by increasing in age. This result is similar to the findings of Magda *et al*. (2010). who reported phenotypic correlation between the2nd week and those of 4th, 6th week body weight ranged from medium to very high (0.43 to 0.86) and between the 4th and 6th week body weight ranged from (0.53 to 0.65), for the three generations. On the other hand, they were found Phenotypic correlations between hatch weight and other body weights(2nd, 4th, and 6th week) were low and ranged from (0.03 to 0.25), for the three generations. As well Momoh *et al*. (2014). reported that Phenotypic correlations between body weight at hatch and week 1, respectively, were weak and not significant with body weights at higher ages. However, at weeks 2, 3 and 4, body weights showed significant phenotypic associations with body weights at weeks 5 and 6. Similar trends were reported by Sharaf (1992), Farahat (1998) and Shalan (1998). Sakunthaladevi, *et al*. (2012) reported that phenotypic correlations between body weight at different ages were medium (0.26 to 0.46) in Black and Brown strains. Also Akbas *et al*. (2004) reported a genetic correlation between 2-weeks weight with 4- weeks weight and for 2-weeks with 6-weeks and 4-weeks with 6- weeks as 0.84, 0.8 and 0.87, respectively. Kocak *et al.* (1995) reported a weak phenotypic correlation (0.11) between 38 days weight and 58 days weight of Japanese quail.

These results point out that the growth in quails can be improved by direct selection for high body weight or it will be concluded that body weight of Japanese quails could be improved by direct selection for high body weight, and these high phenotypic correlations between live weights at younger and older ages support the general view of the possibility of selecting Japanese quails based on early body weight. And also these results point out that the strong and positive Phenotypic relationships as observed between body weights at different ages could mean that the same genes are controlling body weight at different ages.

The genetic correlations between hatch weight and age at first egg in this study were low .The problem of small sample size data could have caused some genetic correlation estimates to go outside parametric range.

In this study linear mathematical model was used to estimate body weight of Japanese quails within the age of quails. the high correlation between age and weight of quails ($r=0.97^{**}$ and $r^2=0.94$) would provide a good estimate for predicting body weight within the age.

Conclusions and Recommendations

Conclusions:

The results indicated that heritability decreased with age. On the other hand, these results pointed out that the growth in quails could be improved by direct selection for high body weight. It also concluded that body weight of Japanese quails could be improved by direct selection for high body weight and high phenotypic correlations between live weights at younger and older ages support the general view of the possibility of selecting Japanese quails based on early body weight. The results showed that strong and positive Phenotypic relationships was observed between body weight at different ages could indicate that the same genes are controlling body weight at different ages.

Form the results of this study, it could be concluded that live weight can be improved by direct selection for high body weight for japanese quail.

Heritability of body weight at hatch and week two in this study was high and moderate that indicate possible selection for weight at an early age which will have a positive effect on weight at a later age.

• The moderate heritability estimate (h2=0.53) of age at first egg reported in this study indicate that the selected of bird was Early sexual maturity have a positive effect on age at first egg at a later age and lead to Short generation interval and high rate of egg production.

The study developed the flowing equation:

body weight (g) = -27.260 +22.141× age (week) by which body weight can be calculated and also the age.

Recommendations:

• More studies are needed to assess the correlation between age and body weight .

• Selection of early high hatch weight of quails for better age at sexual maturity and better body weight at first egg.

• Disposing of quail birds after the sixth week of age being less profitable to raise.

• Finding and building more equations for assessing relationship between age, body weight and productivity.

• possibility of using egg colour for selection of good producers.

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Appendices

Appendix (1)

eggs with a characteristic shell pattern for colour for different females of japanese quail.

Appendix(2)

female for black of japanese quail

Appendix(3)

male for black of japanese quail

Appendix(4):

cloacal gland of the male of japanese quail