REPEATABILITY OF BODY WEIGHT AND EGG PRODUCTION TRAITS IN QUAILS UNDER ZARIA ENVIRONMENT

By

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CERTIFICATION

This thesis titled "Repeatability of Body Weight and Egg Production Traits in Quails Under Zaria Environment" by **Joshua Kaye,** meets the regulations governing the degree of Master of Science of Ahmadu Bello University and is approve for its contributions to scientific knowledge and literary presentation.

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DEDICATION

With all love, I dedicate this work to my fiancée, Miss Mary Emmanuel Ukpabia, in recognition of her love, encouragement and care during the course of the programme.

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ABSTRACT

Forty-eight Japanese quail *(Coturnix coturnix japonica)* hens were individually caged and intensively reared for a period of 28 weeks to study the egg production pattern, egg quality characteristics and the relationships between laying age and repeatability of egg quality characteristics. The results shows that the 165 days egg production characteristics of the birds were, egg number 103 $\pm$ 15, number of clutches 38$\pm$6, clutch size 3.0 $\pm$1.0, number of pauses 38 $\pm$ 4, days pause 54 $\pm$ 14 and pause length 2.0 $\pm$ 1.0 days Significant ($P<0.05$) and positive relationship existed between egg number and clutch size ($r=0.85$) which was negatively related with number of clutches, number of pauses, days paused and pause length ($r = -0.46$ to -0.72). Age of quail hens significantly ($P<0.01 - 0.05$) influenced the measured characteristics, except albumen height, yolk width, albumen weight and shell membrane thickness, respectively. Body weight, egg weight and egg breadth increased with increase in age of the quail hens from 12 to 28 weeks while albumen index and haugh unit were decreased within the same period. Quadratic function was a better estimator of the relationships of age, body weight and egg weight with the egg quality traits than linear function. Repeatability estimates for body weight and egg traits ranges from 0.58 to 0.99 for 12 and 28 weeks, respectively. Repeatability of egg length, yolk plus albumen weight, egg index and shape index showed a linear relationship with age, where as the remaining traits showed a curvilinear relationship with age. The general increase in repeatability of each trait with age indicates that fewer records would be required to adequately characterize the inherent producing ability of each hen for the trait as laying age progressed. At the age of 28 weeks old the pullets attained maximum efficiency in repeatability estimates. This study has shown that

Japanese quails attain a peak production of 86% at 12 weeks (84 days) of age. Egg number increased with clutch size but decreased with number of clutches, number of pauses, days paused and pause length. The expected relative genetic gain per generation of selection for repeated records was inversely related to the magnitude of repeatability. Thus, as laying progressed, repeatability estimates became higher and the expected genetic gain from using additional records decreased and fewer records were required to characterize the pullets for inherent transmitting ability. Four eggs per hen are considered adequate for 12-week egg weight, egg length, egg breadth, albumen width, albumen height, yolk width, yolk height, yolk plus albumen weight, yolk weight, albumen weight, shell + membrane weight, shell plus membrane thickness, shell thickness, shell membrane thickness and haugh unit, 8 eggs are required for albumen index, yolk index, egg index and shape index. The number of eggs for corresponding traits at 28 weeks is 3 or 4. In conclusion, the egg quality characteristics were modified as the quail hens aged and the best criterion for judging the shell strength was the egg shape.

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CHAPTER ONE

INTRODUCTION

The protein consumption from animal origin in Nigeria is significantly lower than in other countries of the world. According to Siddique, (1996) the annual average deficit of meat was 3.81 million metric tonnes and the annual average deficit of chicken egg was 6939 million. With the rapid increase in total population and urbanization, the demand for animal products has been increasing. To meet up the growing demand without importation, the development of the animal industry is imperative. Efforts should be directed to rearing animals that are prolific and have short generation intervals such as pigs, poultry and rabbits (Olubajo, 1976). He further stated that more than 1.68 million tonnes of beef is needed annually to raise animal protein intake in Nigeria to 25g per caput per day. This is hardly possible in view of the present situation, where the economic production of cattle is stationary, if not declining. An immediate solution to this problem could be by focusing on poultry species with shorter generation intervals such as quails.

Bannerman, (1952) stated that there are several native quails in Nigeria, such as the African Blue quail *(Excalfactora adansoni)* which is found in Bauchi and Plateau States, the little Button quail *(Turnix sylvatica Lepurena*) found in central and northern Nigeria, Quail-Plover or the Bush-Lark quail *(Ortyxelos meiffrenii) is* found at the extreme North West of Nigeria. The Harlequim quail *(Coturnix delegorguei delegorguei*) is believed to be resident in Africa but subject to periodic migratory movements which are yet little understood, but believed to be governed by the rainfall. The common quail (C*oturnix coturnix)* found around the North East of Nigeria.

The Japanese quails *(Coturnix coturnix japonica)* native to Asia, were first recorded to be domesticated in the 11th century as song birds. They were introduced into the United States by Fanciers around 1870, but it was not until the early 20th century that they were recognised as food source (egg production only). Their value as research animals were realized in the middle 20th century, when favourable comparism between them and other poultry species were recorded (Cheng and Kinnura, 1990). Since then the Japanese quails have spread all over the world (Sugiyama, 1991; Nitsan, *et al.* 1994).

The Japanese quail was introduced into Nigeria 1992 by the National Veterinary Research Institute (NVRI), Vom, with the support of the Directorate for Food, Road and Rural Infrastructures (DFFRI) through the importation of fertile eggs from the Republic of Benin (Haruna, *et al.,* 1997). Currently over one hundred thousand quails are produced annually for both meat and egg for distribution to farmers as foundation stock for breeding.

In Nigeria quail farming has witnessed rapid expansion in urban areas, producing meat, eggs and quail-chicks/pullets. However, quail farming has not yet been popularised in rural areas. Similarly there have been little empirical studies on the profitability of commercial quail farming and the socio-economic problems faced by the quail farmers. Thus impeding recommendation on its production nation-wide.

Recent advances in genetic selection has made today's quail production quite different from that of a decade ago. For instance, age at 5 percent egg production is now earlier and total production has increased. Quails can product 250-280 eggs per year. Other advantages are shorter generation interval which make it possible to propagate many generations in a year, early sexual maturity (5- 6 weeks), fast growth rate with the

possibility of attaining market weight of 150- 180 gm in 6 week (Shim and Vohra, 1984). They have low floor space requirement because of their small body size, low feed requirement and short incubation period of 17-18 days (Anthony, *et al*; 1993). They are highly resistant to the notorious poultry diseases of chicken (Ajaykumer *et al*; 2000; Sugiyama, 1991). Their droppings which are high in nitrogen can form good compost for vegetables and crops (N V R I, 1990). Quail production can be started with very little capital, and they make excellent materials for biological research because of their size and short generation interval (Padgett and Ivey, 1959). The climate and natural conditions of Nigeria are very suitable for quail rearing. Quail can be reared in this country throughout the year and shows good performance in respect to meat and egg production. It has a short life cycle and its production requires less capital and land. Quail may be a source of income in addition to chicken and ducks because of its immense potentiality for meat and egg production (Paul and Sarker, 1992). In addition, quail meat and eggs are renowned for their high biological but low caloric value thus making them a choice for hypertensive prone patients (George, 2002). However, instinct for hatching and caring for the young is practically absent in domesticated quails (N V R I, 1990). Successful production therefore, requires artificial means of hatching and caring of the young. Similarly, quails are not suitable as free range or backyard scavengers, as predating birds, rats and cats can attack them easily.

In order to cope with the recent ban by federal Government of Nigeria on importation of exotic poultry products amongst other items, and to improve the protein intake of Nigeria per day per caput, some measures have to be taken to provide sufficient animal protein to the citizenry. A good measure is to venture into quail research as a

complement to poultry chicken research. Probably because of the advantages derivable from them. This study was therefore designed with the following objectives:

i. To determine the 165 days egg production pattern of Japanese quails in the northern guinea savannah zone of Nigeria.
ii. To determine the relationships between age and egg quality characteristics.
iii. To estimate repeatability of body weight and egg quality traits.
iv. To determine the relationships between laying age and repeatability of egg weight and egg quality traits.

CHAPTER TWO

LITERATURE REVIEW

2.1 Management of Quails

2.1.1 Brooding and care of young birds

Newly hatched quail chicks are small, therefore proper brooding temperatures are required for about 3-4 weeks after hatching. A commercial brooder or any other heat source that provides sufficient heat could be used successfully, and should be placed 30-46cm above the floor of the pen. The temperature should be measured at the chicks' level and maintained it at about 35^{o}C during the first week of brooding. This temperature may be decreased by about 3.5^{o}C a week until the chicks are fully feathered at about 3-4weeks (NVRI, 1996).

The best guide for adjusting the temperature is chick behaviour. Crowding near the heat source and showing the sign of being cold indicate that the temperature is too low. When the chicks tend to settle a little outside the hottest area, the temperature is about right (Thaxton, 1978). Failure to provide adequate heat during the early days of the brooding period invariably results in increased mortality. Chicks should be protected from draughts of cold air, especially at night (El-ibiary, *et al;* 1966). A gas brooder could be used to provide supplementary heat for quail chicks housed in deep litter.

Care must be taken with small quails to prevent drowning in water troughs. A canning jar with a glass or plastic base or automatic chick mini-drinkers, work well, provided the drinking trough is filled with pebbles or marbles to stop the baby quails from getting into the water. When the chicks reach one week of age, the pebbles could be

removed with safety. It is important to provide clean water at all times, water containers or troughs should be cleaned daily (NVRI, 1996).

Litter is used to dilute the droppings and absorb moisture. Wood shavings, Sawdust and sand are good litter materials. Litter should be 5-10cm deep and covered with paper for the first week. Soft, rough types of paper should be used, as chicks tend to spraddle on hard, smooth paper. Old newspapers are satisfactory but not ideal, paper toweling is better. Feeds should be sprinkled on the paper to encourage young chicks to eat. If chicks are raised in wire cages or on a wire floor, the floor surface must be covered with coarse paper for the first week to prevent leg injuries (NVRI, 1990).

Feather pecking or other forms of cannibalism may occur when Japanese quails are kept on wire. Beak trimming may be necessary as early as 2 weeks of age and is usually done with a hot-blade-type commercial beak trimmer. The tip of the upper beck can be temporarily removed with nail clippers. After birds are beak trimmed, the level of feed and water in the troughs may need to be increased. Other general but effective preventive measures are to reduce the number of birds per pen to avoid crowding, reduce the light intensity and increase the dietary fibre and grit (NVRI, 1996).

2.2 Quail Husbandry

The quail, like other species of poultry kept for commercial purposes, must be given proper care and attention. Environmental conditions should be adjusted according to the climatic condition and the needs of stock of different ages (NVRI, 1996). Dry feed should be available at all times, and drinking water must be cool, clean and readily accessible. Excessive or rough handling may kill them. Sudden noise and disturbances should be avoided. Protection from cats, dogs, rats and predatory birds is essential. If

laying hens are moved to new quarters, a pause in production of 2-3 weeks is likely. Avoid introducing new birds into the territory of an established group (Randall, 2001).

Before the chicks are placed under the brooder the papered floor should be covered with feed and the troughs filled to overflowing. After about a week, when the paper is removed and the chicks have learned to eat, the level of feed in the trough can be lowered to reduce wastage (NVRI, 1990).

2.3 Housing and Equipment

Quails are frequently housed in rooms similar to garages. However, such rooms need to be well insulated, well ventilated and free from draughts, and must provide protection from cats, rodents and predatory birds (Wilson, 1961). Housing should be designed to ensure comfort for the birds, to make food and water readily accessible and to permit easy and effective sanitation. The adult facilities should reflect the purpose of the project. For example, if the birds are to be raised for commercial egg or meat production, then small pair-cages are suitable. Hobbyists may prefer aviaries or small deep-litter pens that do not require regular removal of dropping (NVRI, 1996).

For cage or pen construction, 7mm square welded wire mesh is recommended to provide secure footing, prevent leg injuries and prevent chicks escaping through side walls. According to Clauer, *et al.* (2002), for the adult quails to live and produce successfully they should be allowed 145cm^2 of floor space per bird (70 birds /m^2 deep litter, 80 birds/m^2 wire floor). Often, in community pens, they will not build a nest but will hide their eggs in the litter. For this reason quail egg producers usually prefer to house their birds in cages. A cage 13 x 20m is large enough for two birds. The cages

should have a solid metal or plywood roof to minimize head injuries if the birds take fright.

Adult quail need 1.25-2.5cm of feeder space per bird. Ample feed should be present but if the trough is too full, excessive wastages will occur (Wilson, 1991). Clean, fresh water should be provided at all times with a minimum of 0.6cm of trough space per quail. Nipple drinkers or cups are suitable for adult quails. One nipple or cup should be provided for every 5 birds (Mentis and Bigaike, 1980).

2.4 Light Requirement

The effect of light on egg production is pronounced (Arrington *et al.* 1962). Increasing day – length stimulate laying. Decreasing day-length inhibits egg –production. In practice, a day-length of 14 hours seems to be satisfactory for sustained laying Japanese quails according to (NVRI, 1996) require 14-18 hours of light per day to maintain maximum egg production and fertility. This means that supplementary lighting must be provided in the autumn, winter and spring months to maintain production. Hens under satisfactory conditions will continue to lay while moulting. A total number of 200 eggs per hen could reasonably be expected per year under good conditions with possibility of 260 eggs or more under optimal conditions (UFAW, 1967). The incubation period of Japanese quail ranges between 16 and 18 days.

Males not required for breeding, or any quail being grown for meat production, can be given only about 8 hours of low intensity light per day. This is not enough to initiate sexual maturity, therefore, the birds do not expend energy on fighting and mating and will tend to fatten more quickly (NVRI, 1996).

2.5 Feed formulation and Evaluation

The energy in poultry diets is derived mainly, from maize, millet, sorghum, rice and to some extent wheat. Dietary energy and protein interact because protein and energy are needed for protein turn-over and deposition; and body proteins form part of the stored energy of the body (Bonerman, 1980). The different types of vegetable oil that have been or can be used to increase the energy in poultry diets include palm oil, groundnut oil, melon seed oil and palm Kernel oil. The animal sources are chiefly fish meal, blood meal, milk powder and to some extend meat and blood meal (Schwartz and Allan, 1981).

The minerals needed in formulating a feed can be supplied as micro-nutrients feed additives. Vitamins are given in synthetic forms. These are as effective as those from natural sources and are often preferred for their standard quality, guaranteed potency, stability and full biological availability. Synthetic vitamins are supplied singly or as low potency premixes in combination with active ingredients like minerals, antibiotics and others (Oluyemi and Roberts, 1985).

The feed requirements of birds are largely determined by the anatomy and capabilities of the digestive trait. These determine what type of feeds that can be ingested and digested into the nutrients required to sustain the body and the form in which these nutrients will be delivered to the circulatory system. Alteration and impairments within the digestive system may affect feed utilization and subsequently growth (Weibel and Devegowda, 1982).

In formulating poultry feed, Oluyemi and Robert (1985) remarked that only the levels of the feed ingredients that are compatible with efficiency should be used. According to Waibel and Devegowda (1982) linear programming has been an extremely

important tool in modern ration formulation. This is because it allows the imputing of many nutritional requirements and feeding restrictions and quickly produces a least cost formulation which meets these specifications.

The most reliable assessment of the feed quality is on the basis of its effect on the performance of the birds. However, these effects can be predicted to some extent from the chemical analysis of the diet. The efficiency of feed utilization of the bird is partly genetically determined as the faster growing or the more prolific birds are also more efficient (Oluyemi and Robert, 1985). The quality of a dietary protein is the extent to which its essential amino acid pattern coincides with the needs of the animals. Theoretically, the poorer the protein, the more it would be needed to satisfy the needs for particular nitrogen retention. Therefore maximum nitrogen retention is achievable with a poorer dietary protein but more of the protein will be needed and the rate of increase in nitrogen retention per unit intake of the protein will be less than that of a better protein source (Buttery and Lindsay, 1980). Wethli, *et al,* (1975) showed that young chicks did not achieve maximum weight gain when receiving protein of poor quality, even if enough of such protein had been included in the diet of the chick to satisfy the requirement for the limiting amino acid expressed as a proportion of the diet.

2.6 Nutrition of Quails

A standard ration for either growing or breeding quails may not be available commercially. If this is the case, good quality fresh, commercial turkey or game bird diets are recommended, preferably fed as crumbles to minimize feed wastage. A good quality commercial starter ration for game birds or turkeys contain about 25%-28% protein. If this is not available, a chick starter ration (20%-22%, protein), can be used, but

the birds will grow more slowly (Randall, 2002). For the first 6 weeks, feeds should contain approximately 25% protein, about 12.6mega joules (mj) of metabolisable energy (M.E) per kilogram, and 1.0% calcium.

The dietary requirements for birds nearing maturity are similar except that calcium and phosphorus levels must be increased. Shell grit or ground limestone can be added to the diets after 5 weeks of age, or it may be provided separately free choice. Laying diets should contain about 24% protein, 11.7MJ of metabolisable energy per kilogram and 2.5% -3.0% calcium. The latter may need to be increased to 3.5% in hot weather when the birds eat less food but still require calcium to maintain egg production (Marks, 1991).

An adult Japanese quail eats between 14g and 18g of food per day. Fresh feeds, should be obtained and stored in covered containers with tightly fitting lids in a clean, dry, cool area free from animals and vermin. Feeds stored longer than 8 weeks are subject to vitamin deterioration and rancidity, especially in summer months (Varyhese, 2002).

2.7 Disease Prevention and Control

Sanitary management practices are the best guarantee against disease. Equipment, such as cages, feeders, waterers and tools should be cleaned and sanitised frequently. A commercial disinfectant is recommended (NVRI, 1990). Japanese quails suffer from some of the diseases that affect domestic chickens such as Newcastle disease, fowl typhoid, coccidiosis, fowl pox. However, if housing, nutrition, husbandry and hygiene are of high standard, mortality should not be a problem. Birds that appear sick should be isolated from healthy ones. Dead birds should be removed immediately. A veterinary diagnoses is desirable before initiating treatment.

2.8 Body Weight and Growth in Quails

In chickens, Chineke, (2001) reported consistent increase in body weight gain during the first four weeks, which may be due to genetic and or non genetic factors. Duplessis and Erasmus (1972) and Ayorinde *et al.* (1988) however reported consistent reduction in body weight in laying hens, which they attributed to increased use of physiological reserves to meet egg production demands. Marks, (1979) observed that lines with high body weights produced larger eggs. Changes in body weights of quails with advancing age are similar to those observed for poultry generally (Perek and Snapir, 1970; Roland, 1976; Hamilton, 1978; Hamilton *et al.,* 1979 and Hamilton *et al.* 1964). Such changes are caused by non-genetic factors such as age, maternal effect, feeding, diseases, management and climate and genetic factors such as breed and strain.

2.9 On-Set of Sexual Activity (Puberty)

There are numerous reports on the physiologic relationships associated with on-set of sexual activities in avian females (Marks and Kinney, 1964; Dunnington and Sielgel, 1984; Hocking, 1993; Eitan and Soller, 2001). Previous reports have shown that a number of factors contribute to the considerable variation observed in the on-set of egg production in chickens, turkeys and Japanese quails. The variation is thought to be due to environmental, genetic and physiologic factors including photoperiod, nutrition, body composition, and age of the bird (Hutt, 1964). In Japanese quails and in a line selected for increased 4-week body weight, different photoperiods during rearing had been reported to delay the onset of sexual activity (Nestor, 1985). Oruwari and Brody (1988) however concluded that the interaction between chronological age, body weight, and body composition on the on-set of sexual maturity were inseparable. Others had suggested that

there are multiple thresholds of minimum chronological age, body weight and body composition that influence female sexual development (Dunnington and Siegel, 1984; Soller *et al.,* 1984; Zelenka *et al.,* 1984).

The early sexual maturity of Japanese quail is remarkable. Females have been known to lay as early as at 58 days (7-8 weeks) if conditions are optimal. In addition, male early sexual maturity is similar to that of the female, at least as far as spermatogenesis is concerned (Padgett and Irey, 1959, 1960). However, the fertility of young males may not be as high as in older birds.

2.10 Egg Production Pattern in Quails

Quails start laying after 35 days (Varyhese, 2002) while piano *et al*. (2004) reported 42 days as age of first lay. Properly cared for quail pullets lay approximately 200-300 eggs in 365 days (100-150 eggs in 176 days). Randal (2001), Przywarona, *et al.* (2002) and Varghese, (2002) stated that wild Japanese quails lay eggs in small clutch numbers of 5-12 eggs. Thompson, (2001) however reported quail average clutch size to be 10-12 eggs with clutch sizes being smaller during the dryer years. Randall, (2002) reported that if laying hens are moved to new quarters the number of days paused would increase to 2-3 weeks instead of the normal average pause of 2-3 days. Ibe and Okonkwo (1994) observed that the genotype of individuals and several other genetic and non genetic factors affect egg production traits.

2.11 Relationship Amongst Egg Production Pattern Characteristics

The egg number is correlated to characteristics such as number of clutches, clutch size, number of pauses, total days paused and average total number of days paused either positively (Render *et al.,* 1984) or negatively (Novcher and Kuneuer, 1973; Harms, *et al.,*

1982). Randall, (2001) and Przywarova, *et al.* (2002) observed that with proper care, quail pullets lay approximately 56.18-84% in 365 days/bird. A study conducted on repeated measurements of egg traits in Japanese quails *(Coturnix coturnix japonica)* was observed to be correlated to egg weight (Yannakopoulos and Tserveni-Gousi, 1986).

2.12 Egg Weight and Egg Quality Traits

The changes in the quality of quail egg is similar to those observed by Perek and Snapir (1970), Roland (1976), Hamilton, (1978) and Hamilton *et al.* (1979), for eggs from laying chickens. Yannakopoulos and Tserveni-Gousi, (1986) stated that the proportions of albumen, yolk, and shell plus membrane in the eggs of quails were 53.57%, 32.59% and 7.80%, respectively which also agreed with the finding of Ricklefs and Marks (1993).

Fletcher *et al.* (1983), observed that quail eggs had lower proportion of albumen but higher proportions of yolk than chicken eggs. According to Asmundsen *et al.* (1943), quail eggs have stronger shell membranes as judged by their weight expressed as a proportion of egg weight, than hen eggs (2.61% compared with 0.63%). Yannakopoulos and Tserveni-Gousi, (1986), Fletcher et al; (1981) reported that, as the age of laying hens increased, egg weight, dry shell weight, deformation and the proportion of yolk increased. Ibe and Okonkwo, (1994) indicated that factors that influence changes in egg quality traits are both genetic and non-genetic in nature.

2.13 Estimation of Relationship between Traits

Jull, (1924) reported egg traits of hens to be highly correlated with the body weight. It had also been observed that egg shape in chickens is affected by shell thickness (Hammerle, 1969). The egg shell structure of quails (Andujar *et al;* 1978) is similar to

that of hens (Taylor, 1970). Thus there should also be close association between shell thickness and egg shape in quails.

Genetic correlations between total egg and the weights of its component parts were well above 0.5 (Baumgartner, 1994; Minvielle et al; *1997) but the former author reported a negative correlation (-0.53) with yolk cholesterol concentration. High genetic correlation between shell and yolk heights (0.54 and 0.53) and the absence of significant genetic correlation between shell weights and the ratio yolk / albumen were observed in two selected quail lines (Minvielle* et al; *1997).*

2.14 Estimation of Genetic Parameters

A lot of investigations have been carried out on the changes that occur in the production process of the domestic chicken throughout the course of the laying period (Wolford and Tanaka, 1970). However, less detailed information is available on such changes in quails (Wilson *et al;* 1979; Itoh *et al.*, 1980, Ricklefs and Marks, 1983; Marks and Kinney, 1984).

Adeogun and Adeoye (2004) observed that body weight increased as the quail birds advances in age with heritability estimates of body weights ranging from 0.43 $\pm$ 0.18 to 1.08 $\pm$ 0.17 using full sibs analysis. They further indicated that the mean (SD) for the quail body weight at day old, first, second, third, fourth, fifth and sixth weeks were 7.74 $\pm$ 0.55, 22.3 $\pm$ 3.23, 47.2 $\pm$ 4.77, 89.5 $\pm$ 6.16, 123 $\pm$ 7.60, 161 $\pm$ 9.90 and 197 $\pm$ 12.16g, respectively. Baumgartner, (1993) recorded the heritability values for body weights range of 0.20 to 0.80 which is different from heritability value (1.80) for day – old body weight from findings of Adeogun and Adeoye (2004), which is above the

normal range of heritability values. This may be due to uncontrolled effects of lines, sex and generation (Michaska, 1992). Adeogun *et al.* (2004) stated the heritability of body weight of Japanese quail at hatch at seven , fourteen, twenty one, twenty –eight days of age as 0.33, 0.35, 0.36, 0.43 and 0.47, respectively. The result indicated increase with age.

Heritability estimates for body weight at hatch, 7, 14, 21 and 28 days old in Japanese quails were also reported to be 0.38, 0.12, 0.31, 0.12 and 0.44 respectively, when Henderson methodology was used (Aggrey and Cheng, 1994). In Japanese quails, heritability values for body weight between 0.47 – 0.74 at 28 days old were reported by Manville (1998) in a review about animal improvement for production. Saatei *et al.* (2002) reported heritability estimate for body weight of 0.32, 0.20, 0.21, 0.21 and 0.15 at hatch, 7, 14, 21 and 28 days old, respectively in one to one sire and dam pedigree recorded of Japanese quail.

2.15 Repeatability

Okonkwo and Ibe, (1994), Akinokun and Dettmers, (1977) had defined repeatability as the ability of individuals to repeat its performance and maintain its ranking in a population in successive records. The estimation of the future most probable producing ability of each bird is of immense advantage from point of view of shortened generation interval and enhanced expected rate of annual genetic gain. Okonkwo and Ibe, (1994) had stated that traits such as birth weight and slaughter weight can only be measured once during the life time of an animals, where as other traits like body weight and egg quality traits can be measured at several periods. Variations commonly observed in these traits are due to both genetic and non-genetic factors.

There appeared to be limited information in literature regarding repeatability of 28 weeks traits of quails. But similar studies in other commercial pullets were reported by King and Hall (1955) who indicated varying repeatability coefficient values for egg quality traits at different seasons of the year but noted a declining repeatability in the traits with increasing age in lay. Meritt *et al*. (1960), however, observation an increase in repeatability of same traits as laying period progressed. Decrease in maternal influence on egg characteristics as laying period proceeds has been reported by Kosin *et al;* (1952) and Saadeh *et al.* (1968).

Wilhelmson, (1975) reported repeatability estimates in egg traits of quails to be 0.46 - 0.58 while Sooncharenying and Edwards, (1986), reported repeatability coefficients of 0.80 for egg weight, 0.98 for shell weight and 0.85 for shell thickness. Other studies in commercial quail pullets showed repeatability coefficient of haugh unit and shell thickness ranging from 0.39 to 0.72 and from 0.17 to 0.45 (Godfrey *et al.* 1954; King and Hall, 1955; Goodman, 1965 and Ibe, 1984;). Repeatability estimates for egg weight, ranging from 0.57 to 0.98 have been reported for birds of different ages and genetic background such as local chickens, Exotic layers and quails (Ayorinde and Sado, 1988; Ibe, 1984; Goodman, 1965; Scheinberg *et al;* 1953). A range of 0.42 to 0.51 has also been observed for the same traits by Farmswarth and Nordskog (1955). Farnsworth and Nordskog (1955) King and Hall (1955), Goodman, (1965) and Kotiah *et al.* (1974) reported a range of 0.35 to 0.68 for shape index. However, Akinokun and Dettmers, (1977) stated that in addition to the genotype of an individual several non-genetic factors influence repeatability. Amongst these are age, maternal effects and environment.

2.16 Heritability

The first widely available report on genetic parameters of egg composition was published by Wilhelmson (1975). He obtained moderate values for heritability, increasing from 0.14 to 0.32 for yolk weight, albumen weight, shell thickness and albumen height, using the regression of offspring on the dam procedure. Baumgartmer, (1994) however reported higher values, increasing from 0.25 to 0.35 for shell weight, yolk weight and albumen weight. He also estimated heritability of yolk cholesterol content (0.14). The most comprehensive genetic analysis of egg quality was carried out by Stino et al. *(1982) on 19 egg traits, but the data set was made up of only 233 progeny (from 25 sires and 75 dams), three times less than in the work by Wilhelmson (1975). Consequently, the heritability estimates which they also obtained by regression procedure were not entirely similar to those previously published. The values were high (>0.5) for egg shape index, shell weight, specific gravity, albumen weight and yolk index. They were low (≤ 0.2) for shell thickness, haugh units, yolk percentage and blood spots. They were intermediate (around 0.35) for shell %, albumen %, albumen height, yolk weight and yolk colour. Comparisons of values obtained for heritability from sire dam components of variance led Stino* et al. *(1982) to discuss the existence of factors such as dominance and maternal effects, for the various traits. The standard errors of heritability estimates were also high, therefore they preclude definitive answers on gene action from the data set alone. In their study of egg characteristics based upon the production from 323 females, Sato* et al. *(1989a) obtained high values for heritability of egg weight and*

contents (albumen, yolk, shell), albumen height and shell thickness, ranging from 0.62 to 0.84. More recently, Minvielle, (1998) reported high values (>0.5) of heritability for egg weight, shell weight, yolk weight and the ratio of yolk to albumen, by using Restricted Maximum Likelihood under an animal model in lines under directional selection, but with a full-sib family structure enhancing the expression of dominance/maternal effects. However, high heritability (0.46) of yolk weight estimated using Derivative Free Restricted Maximum Likelihood had also been obtained by Schuler et al. *(1996).*

2.17 Selection

However, associates effects on egg components were somewhat different between selection experiments. Several authors have not observed any correlated effect of selection on body weight. Despite a significant difference in egg weight, Altan and Oguz (1996) obtained similar specific gravity and weight of shell per unit surface (40.5 Vs 40.8mg/cm^2) in their line selected for 4-week body weight and in the control line. Similarly, Altan *et al.* (1998) studied various egg quality traits in the same lines, and found only transient differences for yolk, albumen and shell percents, which later disappeared. Regarding the biochemical contents of the egg, Ricklefs and Marks (1983) observed only small inconclusive line differences for percent lipids and percent non-lipid dry matter in their selection experiment.

The observation noticed with all the changes in the estimates may be as a result of factors influencing them. This is similar to the observations of Kosin *et al.* (1952); Lasley, (1968), Merit *et al.* (1960); Sa'adeh *et al.* (1968). Who indicated that as laying

age progressed the observation in changes noticed with the production traits may be due to progressive decline in maternal influence on the egg and body characteristics.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location of the study

The study was conducted in Zaria, at the Poultry unit of the Animal Science Department, Ahmadu Bello University, Samaru – Zaria.

According to Akpa *et al.* (2002), Zaria is within the 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 a mean annual rainfall of 700 – 1400mm, occurring between the months 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 relatively hot, dry weather from March to sometime in April, when the rains begin. The mean minimum and maximum daily temperature is from about 14°C to 24°C during the cool season and from about 19°C to 36°C during the hot season. The relative humidity varies between 19% and 35% in the dry season, and between 63% and 80% in the wet season.

3.2 Birds and their management

During the study, out of the one-hundred and two (102) birds purchased, fifty-two (50) of them were females while fifty (52) were males. The birds, were brought in November, 2003 when they were 3 weeks old and the study lasted till May, 2004, giving a total period of 28 weeks.

One hundred and two (102) quail pullets of three (3) weeks old were purchased from the National Veterinary Research Institute Farm in Vom and reared in a cages of 0.30 x 0.61m^2 / bird.

Regular water supply and ad libitum feeding using feeds made up of 784.46Kcal /g ME, 28%CP for birds aged 3-5 weeks before reducing the crude protein to 24.01% CP. However, the values of Ca = 2.52, P = 0.76, lysine = 1.80, methionine + cystein = 0.89, remained.

Constant sanitation of the pen was carried out. One hundred and two (102) rubber waterers were washed every morning and placed back with clean cool water. The same process was carried out for the feeders and feeding. Observation of the birds/ their medication and vaccination against disease were carefully carried out, even though the birds hardly came down with any known disease. Their hardy condition not withstanding, medication involved giving antibiotics (neoterramycin) to the birds every two (2) months as preventive measure.

3.3 Data collection

The 48 female quails were weighed at the beginning of the experiment and at weekly intervals thereafter. Feeders and waterers were removed in the evening prior to the next day morning weighing in order to get the actual body weights.

Observations on egg started from mid-December 2003 to May, 2004, a total of 165 days. Eggs were collected twice daily (9a.m and 4p.m) and recorded on a chart. Each egg collected was marked according to cage number and the productions were summarized on weekly and individual basis.

3.3.1 Egg Production Characteristics

Egg production characteristics were determined as follows:

- Egg number = total number of eggs produced per birds in 165 days
- A clutch = one batch of egg laid without a skip
  Number of clutches = total number of batches within the laying period.

- Clutch size = total number of eggs laid in a given batch. This was summed up for all the batches and divided by the number of batches.
- Pause = the skipped period between one batch of eggs and another in a given laying period.
- Number of pauses = the total number of the skipped periods in a given laying period. This was averaged for all the birds involved.
- Paused length = the number of days per skip and averaged for all the birds.
- Days paused = total paused length in a giving laying period. Average for all the birds.

3.3.2 Egg Quality Characteristics in Japanese Quails

The first three eggs laid by each bird at week 8, 12, 16, 20, 24 and 28 of age, a total of 731 eggs were used for egg quality determinations. The weight of each egg was first measured. Egg length and egg breadth were also measured to the nearest 0.01mm using Vernier caliper. Each egg was then broken onto a known weight of clean smooth paper that does not absorb liquid immediately and the albumen length, albumen height, yolk length and yolk height, measured to the nearest 0.01mm (using the Vernier caliper). Albumen weight was determined by first taking the weight of yolk and albumen and thereafter the yolk separated and weighed; and the albumen weight was gotten by subtracting yolk weight from yolk and albumen weight. The egg shells of each egg were collected and air dried for one hour after which the shell and membrane weights were taken. All weight measurements were carried out using Mettler PN 1210 (Max 1200g).

A micrometer screw gauge was used to determine shell and membrane thickness. There after the shell was separated from the membrane and shell thickness measured to

the nearest 0.01mm. Shell membrane thickness was then determined by subtracting shell thickness from shell and membrane thickness.

Each egg shape index was determined as the ratio of width to length (Scheinberg *et al,* 1953). The shape index was calculated (Chineke, 2001), using the formula: maximum width / maximum length, so also for albumen index, yolk index, egg index and shape index.

Haugh unit was determined using an expression that relates egg weight to height of albumen (Haugh, 1937), which is the most widely used method in determining albumen quality.

3.4 Statistical Analysis

3.4.1 Egg production pattern of Japanese Quails

Simple statistics was used to summarize the data generated to show the egg production pattern of the quail hens. Correlation and regression analyse were used to determine the relationships between egg number and other egg characteristics.

3.4.2 Egg Quality Characteristics in Japanese Quail

Egg quality data were subjected to analysis of variance, to determine age influence on each parameter in accordance to Steel and Torrie (1980). Differences between means were separated using the multiple range test.

Linear and quadratic regression equations of body and egg characteristics against ages of pullets were computed as described by Younger, (1985) as follows:

$Y= a + bX$ and $Y = a + bX + cX^2$ ……(1)

Where: X = quail age in weeks, Y = body or egg component characteristic, a = intercept b and c = regression coefficients

3.4.3 Repeatability estimates of body weight and egg quality traits in Japanese Quails

Harvey (1987) mixed model least squares and maximum likelihood computer programme was used to estimate variance components, using the following mixed model:

$$Y_{ijk} = \mu + G_i + I_{ij} + E_{ijk} \quad \text{.....(2)}$$

Where Y_{ijk} is the K^{th} record of the j^{th} pullet in the i^{th} group, μ is the overall mean, G_i is the fixed effect of the i^{th} group, I_{ij} is the random effect of the j^{th} pullet within the i^{th} group, and E_{ijk} is the random error. The model yielded the variance component due to differences among individual pullets $\left(\sigma_I^2\right)$ and error variance component $\left(\sigma_e^2\right)$ (Okonkwo and Ibe, 1994). Which were used to obtained estimates of repeatability, using the expression.

$$R = \sigma_I^2 \ / \left(\sigma_I^2 + \sigma_e^2\right) \quad \text{.....(3)}$$

The standard error of the estimate was calculated using a formular described by Becker (1984).

$$\text{S.E (R)} = \frac{2(1-R)^2\left[1+(k-1)R\right]^2}{K(k-1)(n-1)} \quad \text{.....(4)}$$

Where k is the number of records taken on each individual, n is the number of individuals and R is the estimated repeatability of the trait.

The expected relative genetic gain per generation from selection based on repeated records compared with selection on a single record was computed using the following expression due to Lush (1945):

$$G.G = \left\{K \Big/ \left[1+(k-1)R\right]\right\}^{1/2} \quad \text{.....(5)}$$

Where K is the number of records per pullet and R is the repeatability value.

Both linear and quadratic regression models were also fitted to repeatability age data to determine the relationship between them.

The relative genetic gain per generation of selection based on repeated records for 12 and 28 weeks was determined by finding the percentage of body or egg component characteristics per summation of number of records taken on each individual less hundred percent.

CHAPTER FOUR

RESULTS

4.1 Egg Production Pattern of Japanese Quails

A total of 4,827 eggs were produced by the 48 hen quails. Egg collection was done twice daily (9.00a.m to 4.00p.m) and recorded on daily basis on a chart.

Table 4.1 shows the egg production characteristics of the Japanese quails used. The egg number, number of clutches, clutch size, number of pauses, days paused and paused length were 103, 38, 3, 38, 54 days and 2 days, respectively. There were wide variations in the traits measured as indicated by the minimum and maximum for each traits which were further amplified by the coefficient of variation values, ranging from 15% to 33% with the most variable trait being clutch size.

Table 4.1: Mean for 165 days egg production characteristics in Japanese Quail *(Coturnix coturnix japonica)*

Characteristics	N = 48	Mean	SD	Min	Max	CV%
Egg number		103	15	72	133	15
Number of clutch		38	6	29	55	16
Clutch size		3	1	1	4	33
Number of pauses		38	4	28	63	18
Days paused		54	1	27	87	26
Paused length (day)		2	1	1	3	21

N = number of females used.

The correlated relationships amongst the observed traits (Table 4.2) were significant ($P<0.01$) except the relationships of pause length with number of clutches and

number of pauses. The relationships of egg number with number of clutch, number of pauses, days paused and pause length were negative (r = - 0.46 to -0.72) while its relationship with clutch size was positive (r = 0.85). There were in addition, negative relationships between clutch size and number of clutches (r = - 0.84); days paused and clutch size (r = -0.75); and clutch size and pause length (r = -0.27). However, positive relationships existed amongst number of clutches and number of pauses, and days paused; number of pauses and days paused; days paused and pause length.

Table 4.2: Correlated relationship amongst egg production pattern characteristics of Japanese quails.

Characteristics	Egg No	No of Clutches	Clutch size	No Pauses
Number of clutch	-0.46**	-	-	-
Clutch size	0.85**	-0.84**	-	-
Number of pauses	-0.47**	0.82**	0.75**	-
Days paused	-0.72**	0.51**	-0.75**	0.35**
Paused length	-0.55**	-0.10^{NS}	-0.27**	0.02^{NS}

NS = Not significant, ** = P<0.01.

The linear regression equations relating egg number with other egg characteristics are presented in Table 4.3. Although the regression coefficient of egg number on the other egg traits were significant (P<0.01) the coefficients of determination for these relationships were poor (R^2 = 22-30%) except the relationship of egg number with clutch size (R^2 = 72%) and days paused (R^2 = 52%).

Table 4.3: Regression equation for egg number in Japanese quail.

Characteristics	N=48	Coefficient		
		a	b	R^2%
Number of clutches		147.332	-1.172	22**
Clutch size		50.380	18.838	72**
Number of pauses		140.900	-0.999	22**
Days paused		143.4437	-0.762	52**
Paused length		10.078	-25.910	30**

N = number of female used

** P<0.01

Figure 4.1 shows the 24 weeks egg production pattern of the Japanese quails. The graph, shows that a week after the quails started laying, they attained 71% egg production performance which was maintained up to the 10th and 12th week of lay. At the 12th week of lay, a peak production of 86% was attained and maintained to the 17th week. Thereafter, production dropped back to 71% and gradually to 57% at the 22nd week.

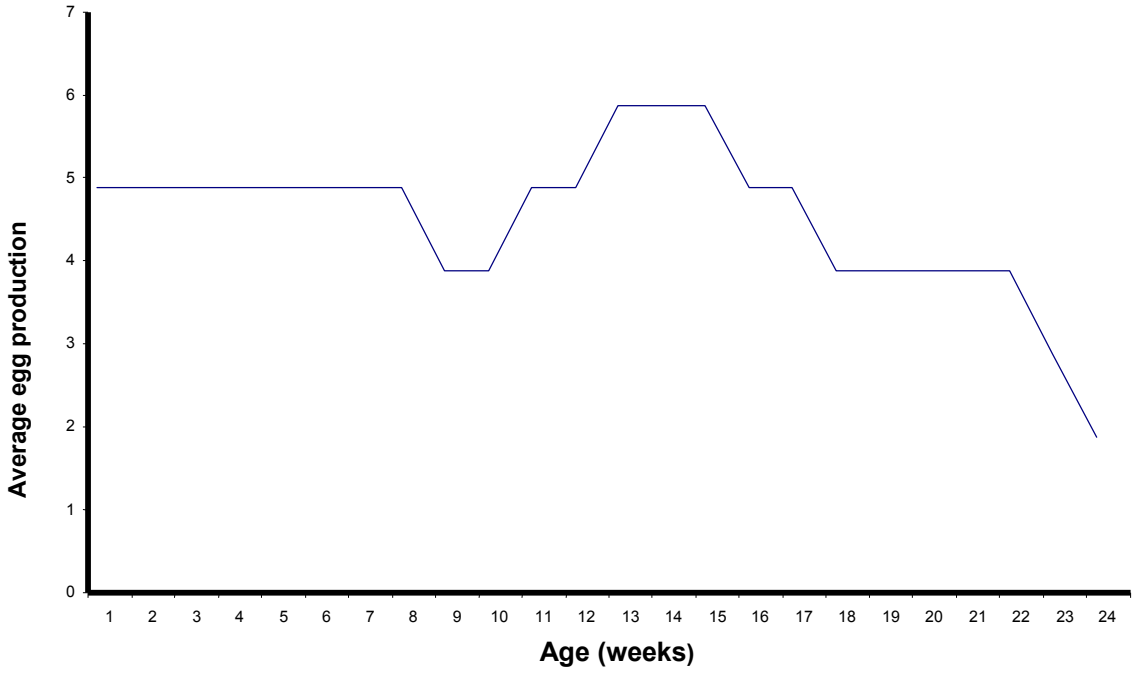


Fig. 4.1: Average egg production pattern of Japanese quail

4.2 Egg Quality Characteristics in Japanese Quails

Table 4.4 presents the means of the measured quail characteristics in relation to age. The overall egg weight was 9.3g. The proportion of albumen, yolk and shell plus membrane in the eggs were 35.5%, 43.0% and 21.5%, respectively. The means of albumen height, yolk width, albumen weight and shell membrane thickens were 0.6mm, 2.4mm, 3.3g and 0.1mm, respectively. Age of quails significantly (P<0.01–0.05) influenced body weight and egg quality traits except albumen height, yolk width, albumen weight and shell membrane thickness. Body weights, egg weights and egg breadths increased from 117.7 to 207.0g, 8.2 to 12.2g and 2.3 to 3.8mm, respectively as the quails advanced in age from 12 to 28 weeks. Egg length was however fairly constant (2.9mm) except for week 8 (2.8mm) and week 16 (2.9mm). Yolk height was constant (1.2mm) except at week 16 (1.1mm). Shell plus membrane

thickness was also constant (0.3mm) except at week 20 (0.2mm). Fluctuating values were observed for albumen width, yolk plus albumen weight, yolk weight and yolk index, ranging from 2.9 – 4.8g, 5.4 – 8.1g, 2.8 – 6.7g and 1.8 – 3.5, respectively within the age range. Shell plus membrane weight increased from week 12 (1.4g) to week 24 (3.4g) and decreased at week 28 (2.0), while albumen index and haugh unit decreased from week 12 to week 28, ranging from 5.7 – 4.5 and 27.0 – 11.7, respectively. The shell thickness, egg index and shape index was constant at 0.2mm, 0.8 and 0.8, respectively for week 12 to week 20 but decreased to a constant value of 0.3mm, 1.3 and 1.3, respectively at week 24 to 28.

The regression of egg quality characteristics against age are presented in Table 4.5. The quadratic (R^2 = 8% - 88%) rather than linear regression (R^2 = 0% - 82%) showed better efficiency in determining the relationships between egg quality traits and quail age. The relationships were significant ($P<0.01– 0.05$) except for albumen weight. Judging from the quadratic function the age of the quails was positively correlated with body weight, egg length, albumen width, yolk plus albumen weight, yolk weight, shell plus membrane weight, shell thickness, albumen index and yolk index. It was negatively correlated with egg weight, egg breadth, albumen height, yolk width, yolk height, albumen weight, shell plus membrane weight, shell membrane thickness, haugh unit, egg index and shape index. Body weight changes most with age. Thus, body weight increased

Table4.4: Means of egg quality characteristics in Japanese quails[1] at different ages.

Traits	Weeks 12	16	20	24	28	Overall mean	SEM	LS
Body weight (g)	117.7±1.88^{d}	187.1±1.87^{c}	193.3±1.86^{bc}	193.3±1.88^{b}	207±1.90^{a}	179.4	1.89	**
Egg Weight (g)	8.2±2.04^{b}	8.1 ± 2.09^{b}	9.9± 2.08^{b}	8.1 ± 2.11^{b}	12.2±2.13^{a}	9.3	0.93	*
Egg length (mm)	2.8±0.07^{b}	2.9 ± 0.07^{b}	3.1 ± 0.07^{a}	2.9 ± 0.07^{b}	2.9±0.07^{b}	2.9	0.03	*
Egg breadth (mm)	2.3±0.68^{b}	2.3 ± 0.70^{b}	2.4 ± 0.69^{b}	2.3 ± 0.70^{b}	3.8±0.71^{a}	2.6	0.31	*
Albumen Width (mm)	3.1±0.83^{b}	2.9±0.85^{b}	3.2±0.85^{b}	4.8±0.86^{a}	2.9±0.87^{b}	3.4	0.38	**
Albumen Height (mm)	0.6±0.01^{a}	0.5±0.01^{a}	0.6±0.01^{a}	0.6±0.01^{a}	0.6±0.01^{a}	0.6	0.00	NS
Yolk Width (mm)	3.5±0.65^{a}	2.0±0.67^{a}	2.2±0.67^{a}	2.2±0.67^{a}	2.1±0.68^{a}	2.4	0.30	NS
Yolk Height (mm)	1.2±0.03^{a}	1.1±0.03^{b}	1.2±0.03^{a}	1.2±0.03^{a}	1.2±0.03^{a}	1.2	0.01	*
Yolk+ Albumen Weight (g)	7.2±0.20^{b}	6.6±0.20^{c}	8.1±0.20^{a}	6.0±0.20^{c}	5.4±0.21^{d}	6.7	0.09	**
Yolk Weight (g)	3.3±1.25^{c}	2.8±1.28^{c}	4.7±1.27^{b}	6.7±1.28^{a}	3.4±1.3^{c}	4.2	0.57	*
Albumen Weight (g)	3.5±0.69^{a}	3.5±0.71^{a}	3.8±0.72^{a}	3.4±0.71^{a}	3.8±0.72^{a}	3.3	0.32	NS
Shell + membrane weight (g)	1.4±0.62^{c}	1.7±0.64^{c}	2.4±0.63^{b}	3.4±0.64^{a}	2.0±0.65^{b}	2.2	0.29	*
Shell + Membrane thickness (mm)	0.3±0.00^{a}	0.3±0.00^{a}	0.2±0.00^{b}	0.3±0.00^{a}	0.3±0.00^{a}	0.3	0.00	**
Shell thickness (mm)	0.2±0.11^{b}	0.2±0.11^{b}	0.2±0.11^{b}	0.3±0.11^{a}	0.3±0.12^{a}	0.2	0.05	*
Shell Membrane thickness (mm)	0.1±0.03^{a}	0.1+0.03^{a}	0.0±0.03^{a}	0.0±0.03^{a}	0.0±0.03^{a}	0.1	0.01	NS
Albumen Index	5.7±0.11^{a}	5.4±012^{b}	5.6±0.12^{a}	4.8±0.12^{c}	4.5±0.12^{d}	5.2	0.05	**
Yolk Index	2.3±0.93^{b}	3.4±0.95^{a}	2.0±0.95^{b}	3.5±0.96^{a}	1.8±0.97b	2.6	0.43	**
Haugh Unit	27.0±5.57^{a}	15.0±5.71^{b}	17.2±5.69^{b}	13.9±5.75^{c}	11.7±5.81^{c}	17.1	2.55	**
Egg Index	0.8±0.23^{b}	0.8±0.24^{b}	0.8±0.26^{b}	1.3±0.24^{a}	1.3±0.36^{a}	0.9	0.11	*
Shape Index	0.8±0.23^{b}	0.8±0.24^{b}	0.8±0.26^{b}	1.3±0.24^{a}	1.3±+0.36^{a}	0.9	0.11	*

- **[1]The number of eggs per hen contributing to the means was 3 in each case.**

- * = P<0.05; ** = P< 0.01, NS = Not significant; a,b,c,d, means within a row with different superscripts are significantly different.

by 25.62g, where as egg length, albumen width, yolk plus albumen weight, yolk weight, shell plus membrane weight, shell thickness, albumen index and yolk index increased by 0.1121mm, 0.15mm, 0.5379g, 1.0846g, 0.6261g, 0.0507mm, 0.1036 and 0.4596, respectively for every unit change in weight. On the other hand, egg weight, egg breadth, albumen height, yolk width, yolk height, albumen weight, shell plus membrane thickness, shell membrane thickness, haugh unit, egg index and shape index decreased with age at the rate of 0.6571g, 0.4250mm, 0.0150mm, 0.5293mm, 0.0154mm, 0.2089g, 0.0357mm, 0.0178mm, 3.3104, 0.0518 and 0.0518, respectively.

The regression of egg quality characteristics on quail body weight are presented in Table 4.6. Generally, the quadratic relationship (R^2 = 11% - 98%) had better efficiency in describing the relationship between body weight and egg quality traits than the linear relationship (1% - 94%). The body weights of quails was significantly ($P<0.01 – 0.05$) and positively correlated with egg length, albumen width, yolk plus albumen weight, yolk weight, shell plus membrane, shell thickness, albumen index and yolk index,. On the other hand, it was significantly ($P< 0.01 – 0.05$) but negatively correlated with egg breadth, albumen height, yolk width, yolk height, albumen weight, shell plus membrane thickness, shell membrane thickness, haugh unit, egg index and shape index.

Yolk plus albumen weight had the highest rate of increase of 6.88g. The rate of increase for egg length, albumen width, yolk weight, shell plus membrane, shell thickness, albumen index and yolk index was 0.179g, 0.1158mm, 0.1856g, 0.0978g, 003lmm, 0.1401 and 0.3161, respectively. On the other hand, the rate of decrease for egg

Table 4.5: Comparation of linear and quadratic relationships between egg quality characteristics and age Japanese quail.

Trait	Equations[1]						
	Linear		R^2 (%)	Quadratic			R^2 (%)
	a	b		a	b	c	
Body weight (g)	87.28	4.62	68**	-105.92	25.6	– 0.505	88**
Egg Weight (g)	5.3	0.2	50**	13.186	-0.6571	0.0214	63**
Egg length (mm)	2.82	0.005	08 ns	1.8343	0.1121	-0.0027	62**
Egg breadth (mm)	1.12	0.075	51**	5.72	-0.425	0.0125	84**
Albumen Width (mm)	2.63	0.375	09*	-0.82	0.4125	-0.0094	21*
Albumen Height (mm)	0.53	0.0025	13*	0.6943	-0.015	0.0004	21*
Yolk Width (mm)	3.7	-0.065	44**	7.9714	-0.5293	0.0116	75**
Yolk Height (mm)	1.13	0.0025	13*	1.2943	-0.0154	0.0004	21*
Yolk + Albumen Weight (g)	8.76	-0.105	40**	2.8457	0.5379	-0.0161	61**
Yolk Weight (g)	2.13	0.1025	17*	-6.905	1.0846	-0.0246	39*
Albumen Weight (g)	3.65	-0.0125	02 ns	5.4571	-0.2089	0.0049	08 ns
Shell + membrane weight (g)	0.73	0.0725	35**	-4.3629	0.6261	-0.0138	63**
Shell + Membrane thickness (mm)	0.28	-0.0001	00 ns	0.6086	-0.0357	0.0009	36**
Shell thickness (mm)	0.0001	0.015	30*	-0.3286	0.0507	-0.0009	32*
Shell Membrane thickness (mm)	0.163	-0.0053	75 **	0.278	-0.0178	0.0003	81**
Albumen Index	6.7	-0.075	82**	5.0571	0.1036	-0.0045	88**
Yolk Index	3.05	-0.0225	03 ns	-1.3857	0.4596	-0.0121	24*
Haugh Unit	32.81	-0.7925	71**	55.974	-3.3104	0.0629	81**
Egg Index	0.25	0.375	75**	1.0714	-0.0518	0.0022	81**
shape Index	0.25	0.375	75**	1.0714	-0.0518	0.0022	81**

*** Significant correlation at P>0.05, ** = significant correlation.**

ns = no significant correlation,

Table 4.6: Comparative efficiency of linear and quadratic relationships between egg quality characteristics and body weight in Japanese quail.

	Equations						
Traits	**Linear**		**R^2 (%)**	**Quadratic**			**R^2 (%)**
	a	**b**		**a**	**b**	**c**	
Egg weight (g)	4.6295	0.026	26*	61.13	-0.7306	0.0024	87**
Egg length (mm)	2.6003	0.0018	33*	1.3998	0.0179	-0.0001	40**
Egg breadth (mm)	1.1026	0.0084	20*	23.955	-0.2976	0.0010	94**
Albumen Width (mm)	2.750	0.0035	02 ^{ns}	-5.6362	0.1158	-0.0040	09*
Albumen Height (mm)	0.6066	-0.0001	01 ^{ns}	1.6986	-0.0148	0.0001	38**
Yolk Width (mm)	5.4385	-0.0169	93**	10.89	-0.0899	0.0002	98**
Yolk Height (mm)	1.2066	-0.0001	01 ^{ns}	2.2986	-0.0148	0.0001	39**
Yolk + Albumen Weight (g)	124.22	18.48	68**	65.44	68.88	-8.400	88**
Yolk Weight (g)	1.8722	0.0128	08 ^{ns}	-11.032	0.1856	-0.0005	12*
Albumen Weight (g)	3.4968	-0.0005	01^{ns}	11.47	-0.1073	0.0003	12*
Shell + membrane weight (g)	0.0486	0.0119	29*	-6.3676	0.0978	-0.0003	33*
Shell + Membrane thickness (mm)	0.3288	-0.0003	05 ^{ns}	-0.7437	-0.0058	-0.0001	10*
Shell thickness (mm)	0.0069	0.0016	11*	-0.1016	0.0031	-0.0001	11*
Shell Membrane thickness (mm)	180.23	5.97	84**	189.62	-3.405	1.8750	91**
Albumen Index	6.9427	-0.0097	43*	-4.2464	0.1401	-0.0005	71**
Yolk Index	2.3577	0.0013	03 ^{ns}	-21.145	0.3161	-0.0010	54**
Haugh Unit	46.307	-0.1633	94**	3.5033	-0.0124	-0.0005	95**
Egg Index	0.2664	0.0041	28*	5.9478	-0.072	0.0002	54**
Shape Index	0.2264	0.0041	28*	5.9478	-0.072	0.0002	54**

*** Significant correlation at P<0.05, ** = significant correlation at P<0.01,**

ns = no significant correlation.

weight, egg breadth, albumen height, yolk width, yolk height, albumen weight, shell plus membrane thickness, shell membrane thickness, haugh unit, egg index and shape index was 0.7306g, 0.2976mm, 0.0148mm, 0.0899mm, 0.0148mm, 0.1073g, 0.0058mm, 3.405mm, 0.0124, 0.072 and 0.072, respectively.

Table 4.7 shows the regression of the egg quality characteristics on egg weight. Except for egg breadth (R^2 = 87%) linear regression was poor in estimating the relationship between egg weight and egg quality characteristics. The relationships were better described using quadratic model. However, the relationship between egg weight and yolk weight and shell plus membrane weight were not significant.

Egg weight was significant ($P<0.01 – 0.05$) and positively related to egg length, albumen height, yolk height, yolk plus albumen weight, albumen weight, albumen index and haugh unit,. It was however negative and significantly ($P <0.01 – 0.05$) correlated with egg breadth, albumen width, yolk width, shell plus membrane thickness, shell thickness, shell membrane thickness, yolk index, egg index and shape index. The highest rate of increase was haugh unit (11.299), where as egg length, albumen height, yolk height, yolk plus albumen, yolk weight, albumen weight and albumen index was 1.0532mm, 0.1217mm, 0.1217mm, 10.113g, 2.251g and 3.2683, respectively. Egg breadth, albumen width, yolk width, shell plus membrane thickness, shell thickness, shell membrane thickness, yolk index, egg index and shape index on the other hand decreased by 2.3834mm, 0.9459mm, 0.3545mm, 0.4962mm, 0.6789mm, 0.1277mm, 3.3287, 1.56856 and 1.5686, respectively.

4.3 Repeatability of Body weight and Egg quality Traits in Japanese Quails

The repeatability estimates of the various traits measured at 12 and 28 weeks of age (Table 4.8) were high except that of shell membrane thickness. They also show that estimates were higher at 28 than at 12 weeks.

The expected genetic gains per generation of selection for egg quality traits at 12,16,20,24 and 28 weeks of age are given in Table 4.9, 4.10, 4.11, 4.12 and 4.13, respectively. Table 4.9 shows that at 12 weeks of age the relative efficiencies of measuring ten egg instead of one to characterize hens were 4.62, 4.98, 4.53, 4.98, 5.02, 4.98, 5.11, 4.80, 4.49 and 5.11% for body weight, egg weight, egg length, egg breadth, albumen width, albumen height, yolk width, yolk height, yolk + albumen weight, yolk weight, respectively. Others were, albumen weight 4.89%, shell + membrane weight 5.24%, shell + membrane thickness 4.44%, shell thickness 5.29%, and shell membrane thickness 7.06%. The values for albumen index, yolk index, haugh unit, egg index and shape index were 4.49, 5.15, 5.15, 5.06, and 5.06%, respectively.

The relative efficiencies of measuring ten eggs, instead of one to characterize quail hens at 16 weeks of age (Table 4.10) for body weight, egg weight, egg length, egg breadth, albumen width, albumen height, yolk width, yolk height, yolk + albumen weight and yolk weight percentage were 4.68, 5.10, 4.68, 5.14, 5.14, 4.63, 5.23, 4.68, 4.63 and 4.68 respectively. Others were 5.00, 5.28, 4.59, 5.46 and 6.01% for albumen weight, shell thickness and shell membrane weight, shell thickness and shell membrane thickness, respectively. Further estimates were albumen index 4.64%, yolk index 5.14%, haugh unit 5.33%, egg index 5.14% and shape index 5.14%.

At 20weeks of age (Table 4.11) the relative efficiencies of measuring ten eggs instead of one to characterize hens for body weight, egg weight, egg length, egg breadth, albumen width, albumen height, yolk + albumen weight, yolk weight, albumen weight, shell + membrane weight, shell + membrane thickness and shell thickness was 4.64, 5.10, 4.69, 5.15, 5.10, 4.64, 5.15, 4.64, 5.10, 5.01, 5.01, 4.60, and 5.38%, respectively. Values for other traits were shell membrane thickness 5.93% albumen index 4.64%, yolk index 5.01%, haugh unit, 5.24%, egg index 5.10% and shape index 5.10%.

At 24 weeks of age, the relative efficiencies of measuring ten eggs instead of one to characterize hens (Table 4.12) was 4.71, 5.04, 4.71, 5.18, 5.08, 4.71, 5.22, 4.71, 4.67 and 5.04% for body weight, egg weight, egg length, egg breadth, albumen width, albumen height, yolk width, yolk height, yolk + albumen weight, yolk weight, respectively. Others were albumen weight 5.04%, shell + membrane weight 5.04%, shell + membrane thickness 4.67%, shell thickness 5.04% and shell membrane thickness 6.02%. The value for albumen index, yolk index, haugh unit, egg index and shape index were 4.71, 5.13, 5.22, 5.04, and 5.04%, respectively.

The relative efficiencies of measuring ten eggs instead of one to characterize hens at 28 weeks of age are presented in Table 4.13. The result indicates the following relative efficiency values at 28 weeks of quail age: body weight 4.70%, egg weight 5.07%, egg length 4.70%, egg breadth 5.07%, albumen width 5.07%, albumen height 4.70%, yolk width 5.21%, yolk height 4.70%, yolk + albumen weight 4.70%, yolk weight 5.07% and albumen weight 5.07%. Others were shell membrane weight 5.07%, shell + membrane thickness 4.70%, shell thickness 5.07% and shell membrane thickness 6.00%. Albumen index 4.70% yolk index 5.70% and shape index 5.70%.

Table 4.7: Comparative efficiency of linear and quadratic relationships between egg weight and egg quality characteristics of Japanese quail hens.

	Equations[1]						
Traits	**Linear**		**R^2 (%)**	**Quadratic**			**R^2 (%)**
	a	**b**		**a**	**b**	**c**	
Egg length (mm)	2.7537	0.0179	9.0*	-2.2966	1.0532	-0.0154	79**
Egg breadth (mm)	-.5692	0.3429	87**	12.73	-2.3834	0.1354	100**
Albumen Width (mm)	5.0578	-0.1804	16*	8.7917	-0.9457	0.038	17*
Albumen Height (mm)	0.4932	0.0093	14*	-0.0551	0.1217	-0.0056	19*
Yolk Width (mm)	3.4703	-0.1151	11*	4.6381	-0.3545	0.0119	11*
Yolk Height (mm)	1.0932	0.0093	14*	0.5449	0.1217	-0.0056	19*
Yolk + Albumen Weight (g)	8.4824	-0.1960	11*	41.804	10.113	-0.5118	88**
Yolk Weight (g)	5.8795	-0.1827	4.0 ^{ns}	-10.742	3.2246	-0.1692	8.0 ^{ns}
Albumen Weight (g)	1.6861	0.1843	33*	-8.3993	2.251	-0.1027	43**
Shell + membrane weight (g)	2.4837	-0.0327	1.0 ^{ns}	-2.6041	1.0103	-0.0518	2.0 ^{ns}
Shell + Membrane thickness (mm)	0.3234	-0.0047	4.0 ^{ns}	2.7212	-0.4962	0.0244	99**
Shell thickness (mm)	0.4374	-0.0148	2.0^{s}	3.6771	-0.6789	0.033	14*
Shell Membrane thickness (mm)	0.1744	-0.0125	34*	0.7365	-0.1277	0.0057	41**
Albumen Index	6.7187	-0.1633	31*	-10.021	3.2683	-0.1704	65**
Yolk Index	5.7747	-0.3414	59**	20.347	-3.3287	0.1483	70**
Haugh Unit	31.5170	-1.5653	22*	31.237	11.299	-0.6387	26*
Egg Index	0.3853	0.0661	19*	8.3593	-1.5686	0.0812	47**
Shape Index	0.3853	0.6610	19*	8.3593	-1.5686	0.0812	47**

*** Significant correlation at P<0.05, ** = significant correlation at P<0.01,**

ns = no significant correlation.

Table 4.8 Repeatability estimates of various trait in quails.

	Weeks	
Traits	12	28
Body weight (g)	0.92	0.99
	(0.0004)	(0.0000)
Egg weight (g)	0.77	0.85
	(0.0024)	(0.0016)
Egg length (mm)	0.95	0.99
	(0.0001)	(0.0000)
Egg breadth (mm)	0.77	0.84
	(0.0024)	(0.0130)
Albumen width (mm)	0.76	0.83
	(0.0059)	(0.0016)
Albumen height (mm)	0.96	0.99
	(0.0001)	(0.0000)
Yolk width (mm)	0.73	0.79
	(0.0031)	(0.0021
Yolk height (mm)	0.85	0.99
	(0.0016)	(0.0000)
Yolk + Albumen weight (g)	0.97	0.99
	(0.0001)	(0.0000)
Yolk weight (g)	0.73	0.85
	(0.0031)	(0.0016)
Albumen weight (g)	0.80	0.84
	0.0019)	(0.0130)
Shell + membrane weight (g)	0.69	0.85
	(0.0086)	(0.0016)
Shell+ membrane thickness (mm)	0.99	0.99
	(0.0000)	(0.0000)
Shell thickness (mm)	0.67	0.85
	(0.0042)	(0.0016)
Shell membrane thickness (mm)	0.33	0.58
	(0.0088)	(0.0058)
Albumen Index	0.98	0.99
	(0.0000)	(0.0000)
Yolk Index	0.72	0.85
	(0.0033)	(0.0016)
Haugh Unit	0.71	0.80
	(0.0035)	(0.0019
Egg Index	0.75	0.85
	(0.0028)	(0.0016)
Shape Index	0.75	0.85
	(0.0028)	(0.0016)

Standard Errors are in Parenthesis

Table 4.9: Relative genetic gain per generation of selection based on repeated records for 12-week body weight and egg quality trait.

Traits	Number of Records										
	1	2	3	4	5	6	7	8	9	10	280
Body weight (g)	1.00	1.02	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.04
Egg weight (g)	1.00	1.06	1.09	1.10	1.11	1.11	1.12	1.12	1.12	1.12	1.14
Egg length (mm)	1.00	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Egg breadth (mm)	1.00	1.06	1.09	1.10	1.11	1.11	1.12	1.12	1.12	1.12	1.14
Albumen width (mm)	1.00	1.07	1.09	1.11	1.11	1.12	1.12	1.13	1.13	1.13	1.14
Albumen height (mm)	1.00	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Yolk width (mm)	1.00	1.08	1.11	1.12	1.13	1.14	1.14	1.14	1.15	1.15	1.17
Yolk height (mm)	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.09
Yolk + Albumen weight (g)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk weight (g)	1.00	1.08	1.11	1.12	1.13	1.14	1.14	1.14	1.15	1.15	1.17
Albumen weight (g)	1.00	1.05	1.07	1.08	1.09	1.10	1.10	1.10	1.10	1.10	1.12
Shell + membrane weight (g)	1.00	1.09	1.13	1.14	1.15	1.16	1.17	1.17	1.17	1.18	1.20
Shell+ membrane thickness (mm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shell thickness (mm)	1.00	1.09	1.13	1.15	1.17	1.17	1.18	1.19	1.19	1.19	1.22
Shell membrane thickness (mm)	1.00	1.23	1.34	1.42	1.47	1.50	1.53	1.56	1.57	1.59	1.73
Albumen Index	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk Index	1.00	1.08	1.11	1.13	1.12	1.14	1.15	1.15	1.15	1.16	1.18
Haugh Unit	1.00	1.08	1.11	1.13	1.14	1.15	1.15	1.16	1.16	1.16	1.19
Egg Index	1.00	1.07	1.10	1.11	1.12	1.12	1.13	1.13	1.14	1.14	1.15

Shape Index	1.00	1.07	1.10	1.11	1.12	1.12	1.13	1.13	1.14	1.14	1.15

Table 4.10: Relative genetic gain per generation of selection based on repeated records for 16-week body weight and egg quality trait.

Traits	Number of Records										
	1	2	3	4	5	6	7	8	9	10	280
Body weight (g)	1.00	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Egg weight (g)	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.01	1.11	1.12
Egg length (mm)	1.00	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Egg breadth (mm)	1.00	1.06	1.09	1.05	1.11	1.11	1.12	1.12	1.12	1.12	1.14
Albumen width (mm)	1.00	1.06	1.09	1.05	1.11	1.11	1.12	1.12	1.12	1.12	1.14
Albumen height (mm)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk width (mm)	1.00	1.07	1.10	1.11	1.12	1.12	1.13	1.13	1.13	1.14	1.15
Yolk height (mm)	1.00	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.03
Yolk + Albumen weight (g)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.10	1.02
Yolk weight (g)	1.00	1.06	1.08	1.09	1.10	1.11	1.11	1.11	1.11	1.12	1.13
Albumen weight (g)	1.00	1.05	1.06	1.07	1.08	1.08	1.08	1.08	1.09	1.09	1.10
Shell + membrane weight (g)	1.00	1.08	1.10	1.12	1.13	1.14	1.14	1.14	1.15	1.15	1.17
Shell+ membrane thickness (mm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Shell thickness (mm)	1.00	1.09	1.13	1.15	1.16	1.17	1.17	1.18	1.18	1.19	1.10
Shell membrane thickness (mm)	1.00	1.14	1.11	1.24	1.26	1.27	1.28	1.29	1.30	1.31	1.36
Albumen Index	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk Index	1.00	1.06	1.08	1.09	1.10	1.11	1.11	1.21	1.11	1.12	1.13
Haugh Unit	1.00	1.08	1.11	1.13	1.14	1.14	1.15	1.15	1.15	1.16	1.18
Egg Index	1.00	1.06	1.08	1.09	1.10	1.11	1.11	1.11	1.11	1.12	1.13
Shape Index	1.00	1.06	1.08	1.09	1.10	1.11	1.11	1.11	1.11	1.12	1.13

Table 4.11 **Relative genetic gain per generation of selection based on repeated records for 20-week body weight and egg quality trait.**

Traits	Number of Records										
	1	2	3	4	5	6	7	8	9	10	280
Body weight (g)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.02
Egg weight (g)	1.00	1.05	1.06	1.07	1.08	1.08	1.08	1.08	1.09	1.09	1.10
Egg length (mm)	1.00	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Egg breadth (mm)	1.00	1.06	1.08	1.09	1.10	1.11	1.11	1.11	1.11	1.12	1.13
Albumen width (mm)	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.12
Albumen height (mm)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk width (mm)	1.00	1.06	1.09	1.10	1.11	1.11	1.12	1.12	1.12	1.12	1.14
Yolk height (mm)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.02
Yolk + Albumen weight (g)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk weight (g)	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.12
Albumen weight (g)	1.00	1.05	1.06	1.07	1.08	1.08	1.08	1.08	1.09	1.09	1.10
Shell + membrane weight (g)	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.12
Shell+ membrane thickness (mm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Shell thickness (mm)	1.00	1.08	1.12	1.14	1.15	1.15	1.16	1.16	1.17	1.17	1.19
Shell membrane thickness (mm)	1.00	1.13	1.19	1.22	1.24	1.26	1.27	1.28	1.28	1.29	1.33
Albumen Index	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk Index	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.12
Haugh Unit	1.00	1.07	1.10	1.11	1.12	1.12	1.13	1.13	1.13	1.14	1.15
Egg Index	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.12
Shape Index	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.12

Table 4.12. Relative genetic gain per generation of selection based on Repeated Records for 24-week body weight and egg quality trait.

Traits	Number of Records										
	1	2	3	4	5	6	7	8	9	10	280
Body weight (g)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Egg weight (g)	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09
Egg length (mm)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Egg breadth (mm)	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.12
Albumen width (mm)	1.00	1.05	1.06	1.07	1.08	1.08	1.08	1.08	1.09	1.09	1.10
Albumen height (mm)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk width (mm)	1.00	1.06	1.09	1.10	1.11	1.11	1.12	1.12	1.12	1.12	1.14
Yolk height (mm)	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk + Albumen weight (g)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yolk weight (g)	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09
Albumen weight (g)	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09
Shell + membrane weight (g)	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09
Shell+ membrane thickness (mm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shell thickness (mm)	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09
Shell membrane thickness (mm)	1.00	1.13	1.19	1.22	1.24	1.26	1.27	1.28	1.28	1.29	1.33
Albumen Index	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Yolk Index	1.00	1.05	1.07	1.08	1.09	1.10	1.10	1.10	1.10	1.10	1.12
Haugh Unit	1.00	1.06	1.09	1.10	1.11	1.11	1.12	1.12	1.12	1.12	1.14
Egg Index	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09
Shape Index	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09

Table 4.13. Relative genetic gain per generation of selection based on repeated records for 28-week body weight and egg quality trait.

Traits	Number of Records										
	1	2	3	4	5	6	7	8	9	10	280
Body weight (g)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Egg weight (g)	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08
Egg length (mm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Egg breadth (mm)	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09
Albumen width (mm)	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08
Albumen height (mm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Yolk width (mm)	1.00	1.06	1.08	1.09	1.10	1.10	1.10	1.11	1.11	1.11	1.12
Yolk height (mm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Yolk + Albumen weight (g)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Yolk weight (g)	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08
Albumen weight (g)	1.00	1.04	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.09
Shell + membrane weight (g)	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08
Shell+ membrane thickness (mm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Shell thickness (mm)	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08
Shell membrane thickness (mm)	1.00	1.13	1.18	1.21	1.23	1.24	1.25	1.26	1.26	1.27	1.31
Albumen Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
Yolk Index	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08
Haugh Unit	1.00	1.05	1.07	1.08	1.09	1.10	1.10	1.10	1.10	1.10	1.02
Egg Index	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08
Shape Index	1.00	1.04	1.05	1.06	1.07	1.07	1.07	1.07	1.07	1.08	1.08

Table 4.14: Repeatability estimates of body weight and egg quality traits at different ages.

Traits	Weeks				
	12	16	20	24	28
Body weight (g)	0.92 (0.0004)	0.96 (0.0001)	0.97 (0.0001)	0.98 (0.0000)	0.99 (0.0000)
Egg weight (g)	0.77 (0.0024)	0.79 (0.0021)	0.83 (0.0015)	0.84 (0.0130)	0.85 (0.0016)
Egg length (mm)	0.95 (0.0001)	0.96 (0.0001)	0.96 (0.0001)	0.98 (0.0000)	0.99 (0.0000)
Egg breadth (mm)	0.77 (0.0024)	0.77 (0.0024)	0.78 (0.0022)	0.79 (0.0021)	0.84 (0.0130)
Albumen width (mm)	0.76 (0.0059)	0.77 (0.0024)	0.79 (0.0021)	0.83 (0.0015)	0.83 (0.0016)
Albumen height (mm)	0.96 (0.0001)	0.97 (0.0001)	0.98 (0.0000)	0.98 (0.0000)	0.99 (0.0000)
Yolk width (mm)	0.73 (0.0031)	0.75 (0.0028)	0.77 (0.0059)	0.77 (0.0059)	0.79 (0.0021
Yolk height (mm)	0.85 (0.0016)	0.95 (0.0001)	0.97 (0.0001)	0.98 (0.0000)	0.99 (0.0000)
Yolk + Albumen weight (g)	0.97 (0.0001)	0.97 (0.0001)	0.98 (0.0000)	0.99 (0.0000)	0.99 (0.0000)
Yolk weight (g)	0.73 (0.0031)	0.78 (0.0022)	0.79 (0.0021)	0.84 (0.0130)	0.85 (0.0016)
Albumen weight (g)	0.80 0.0019)	0.83 (0.0015)	0.83 (0.0015)	0.84 (0.0130)	0.84 (0.0130)
Shell + membrane weight (g)	0.69 (0.0086)	0.73 (0.0031)	0.79 (0.0021)	0.84 (0.0130)	0.85 (0.0016)
Shell+ membrane thickness (mm)	0.99 (0.0000)	0.99 (0.0000)	0.99 (0.0000)	0.99 (0.0000)	0.99 (0.0000)
Shell thickness (mm)	0.67 (0.0042)	0.68 (0.0040)	0.70 (0.0037)	0.84 (0.0130)	0.85 (0.0016)
Shell membrane thickness (mm)	0.33 (0.0088)	0.54 (0.0065)	0.56 (0.0062)	0.56 (0.0062)	0.58 (0.0058)
Albumen Index	0.98 (0.0000)	0.98 (0.0000)	0.98 (0.0000)	0.98 (0.0000)	0.99 (0.0000)
Yolk Index	0.72 (0.0033)	0.78 (0.0022)	0.79 (0.0021)	0.80 (0.0019)	0.85 (0.0016)
Haugh Unit	0.71 (0.0035)	0.72 (0.0033)	0.75 (0.0028)	0.77 (0.0059)	0.80 (0.0019
Egg Index	0.75 (0.0028)	0.78 (0.0022)	0.79 (0.0021)	0.84 (0.0130)	0.85 (0.0016)
Shape Index	0.75 (0.0028)	0.78 (0.0022)	0.79 (0.0021)	0.84 (0.0130)	0.85 (0.0016)

Standard errors are in parenthesis

Table 4.15 Comparative efficiency of linear and quadratic relationships between repeatability of measured traits with laying age

Traits	Equations						
	Linear		R^2(%)	Quadratic			R^2(%)
	a	b		a	b	c	
Body weight (g)	0.004	0.884	88	-0.0003	0.0147	0.7854	96
Egg weight (g)	0.005	0.711	93	-0.0002	0.0142	0.6289	97
Egg length (mm)	0.0025	0.92	100	-0.0017	0.0025	0.92	100
Egg breadth (mm)	0.004	0.71	75	0.0004	0.0139	0.8743	96
Albumen width (mm)	0.006	0.68	96	0.0002	– 0.0011	0.7457	98
Albumen height (mm)	0.0017	0.941	94	0.0005	0.0035	0.9246	96
Yolk width (mm)	0.0077	0.793	75	-0.0008	0.0417	0.4809	96
Yolk height (mm)	0.0035	0.692	75	0.0005	0.0071	0.0591	95
Yolk + Albumen weight (g)	0.0015	0.95	90	0.0017	0.0015	0.95	90
Yolk weight (g)	0.0075	0.648	95	- 0.0002	0.0146	0.5823	96
Albumen weight (g)	0.0023	0.783	75	-0.0002	0.0112	0.7009	92
Shell + membrane weight (g)	0.0108	0.565	96	-0.0003	0.0233	0.45	98
Shell thickness (mm)	0.013	0.488	85	0.0005	– 0.0084	0.6851	88
Shell membrane thickness (mm)	0.0175	0.21	91	-0.0008	0.0496	- 0.0857	96
Albumen Index	0.0005	0.972	50	0.0005	– 0.0031	1.0049	86
Yolk Index	0.007	0.648	90	0.0005	0.0106	0.6151	91
Haugh Unit	0.0058	0.635	98	0.0021	0.0101	0.696	99
Egg Index	0.0065	0.672	95	-0.017	0.0065	0.672	95
Shape Index	0.0065	0.672	95	0.0021	0.0101	0.696	95

The relative genetic gain increased for all traits at different ages, with increasing number of records on each individual. However, the rates of increase were smaller for traits with high repeatability values.

4.4 The Relationship between laying Age and Repeatability of Egg Quality Traits in Japanese Quails

Table 4.14 shows the repeatability estimates of the measured characteristics. The repeatability estimates of these traits for 12, 16, 20, 24 and 28 weeks were very high, ranging from 0.70 to 0.99 with the exception of those of shell thickness which was 0.67 at 12 weeks and 0.68 at 16 weeks, and those of shell membrane thickness at 12, 16, 20, 24 and 28 weeks values of 0.33, 0.54, 0.56, 0.56, and 0.58, respectively.

Table 4.15 presents the comparative efficiency of linear and quadratic regression models between laying age and repeatability values of measured traits. The linear regression model significantly and efficiently (R^2 = 75-100%) estimated the relationship between laying age and the repeatability of the measured traits, except in the case of the shell membrane thickness (R^2 = 50%). The quadratic model similarly significantly better efficiency (R2 = 86-100%) estimated the relationship between laying age and the repeatability of the measured traits but with better efficiency (R^2 = 86-100%).

The regressions of the better-fitting models of repeatability on age of birds are presented in Figures 4.2 - 4.24. Repeatability of egg length, yolk and albumen weight, egg index and shape index increased linearly with laying age. The rate of increase were 0.0025, 0.0015, 0.0005 and 0.0065 units per week, respectively. While for the curvilinear relationship is at maximum for folk height and albumen weight at week 24 and 25, respectively.

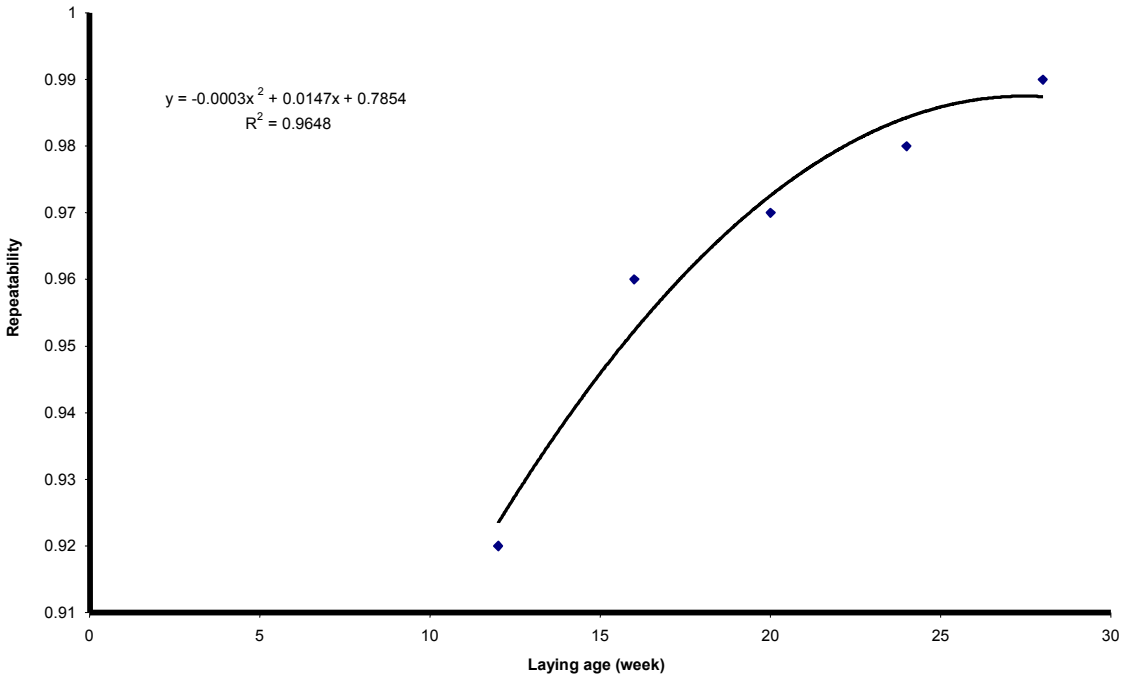


Fig 4.2: Relationship between repeatability of body weight (g) and laying age (weeks)

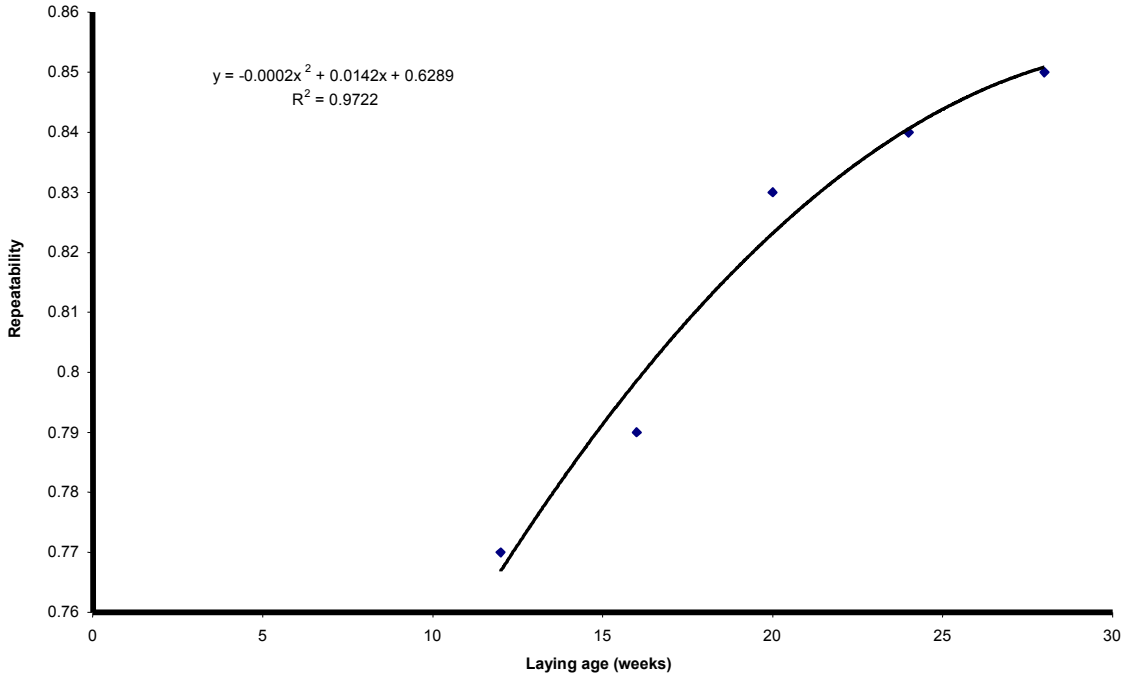


Fig 4.3: Relationship between repeatability of egg weight (g) and laying age (weeks)

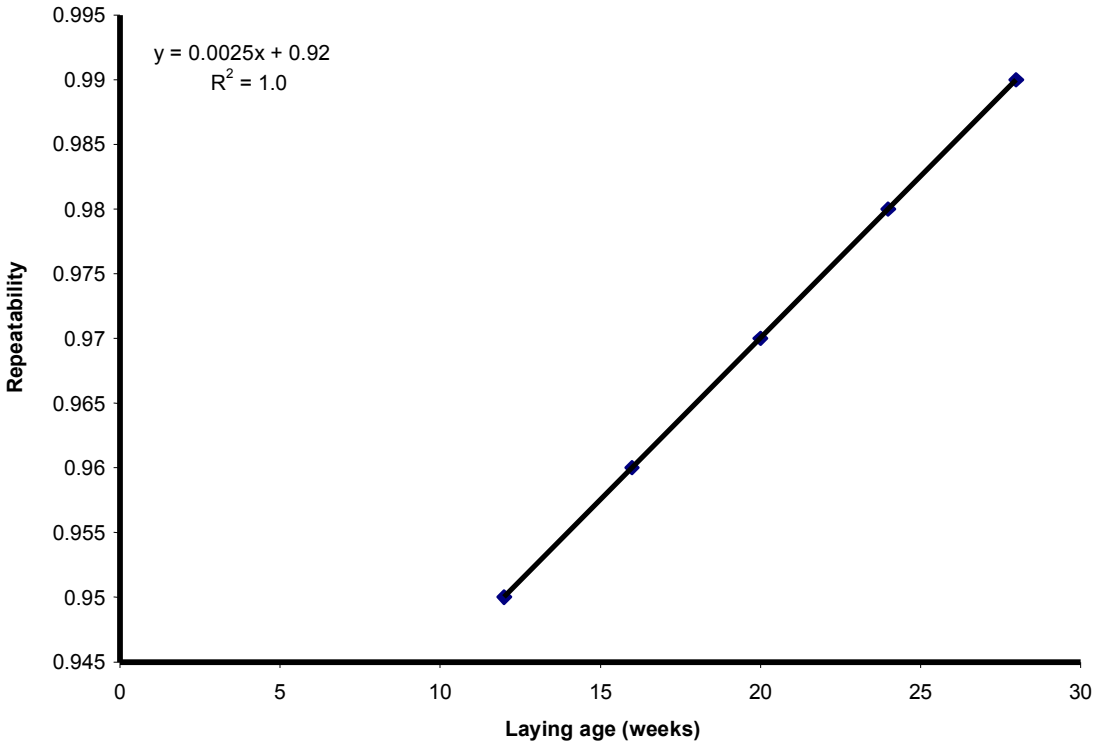


Fig 4.4: Relationship between repeatability of egg length (mm) and laying age (weeks)

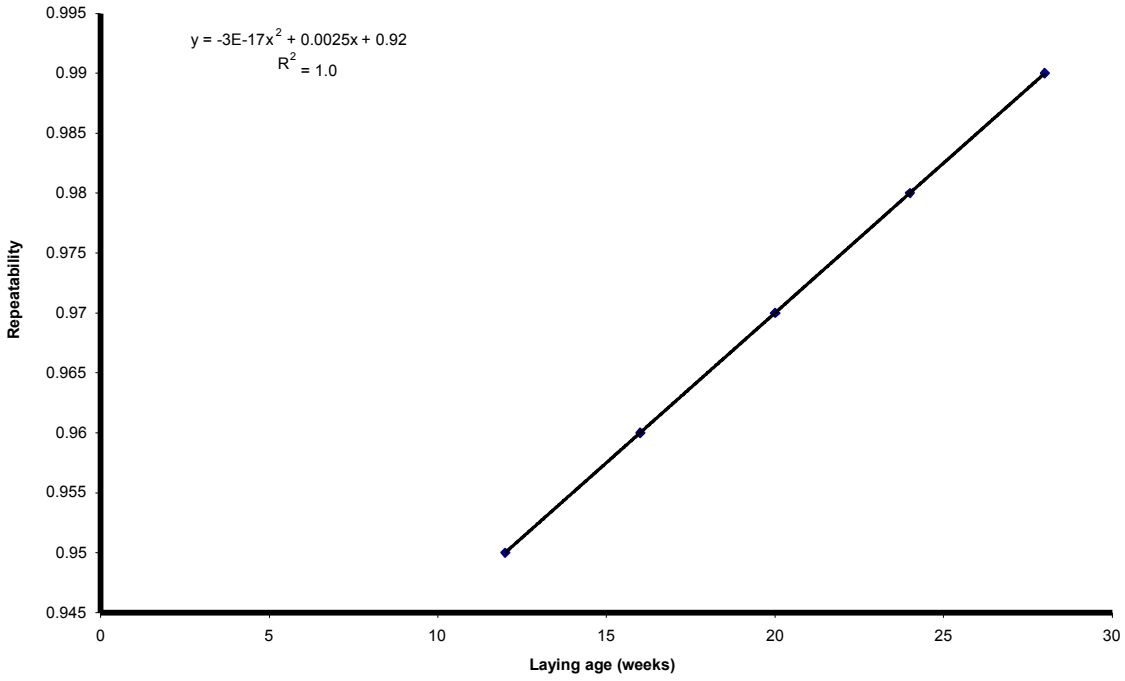


Fig 4.5: Relationship between repeatability of egg length (mm) and laying age (weeks)

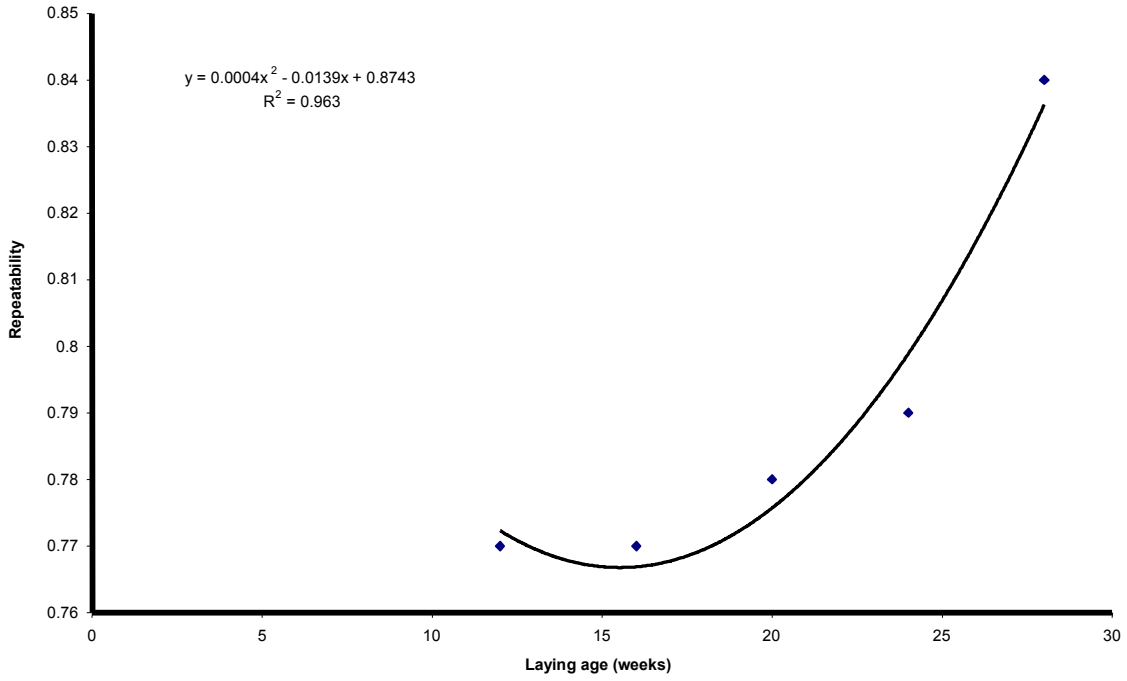


Fig 4.6: Relationship between repeatability of egg breath (mm) and laying age (weeks)

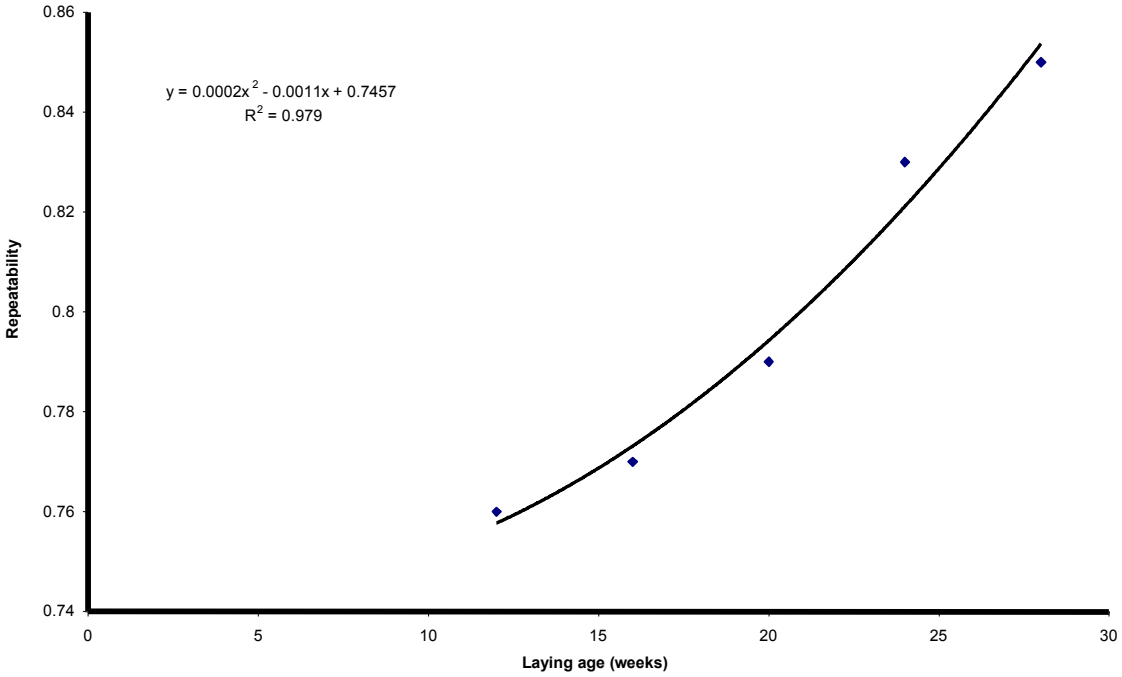


Fig 4.7: Relationship between repeatability of albumen width (mm) and laying age (weeks)

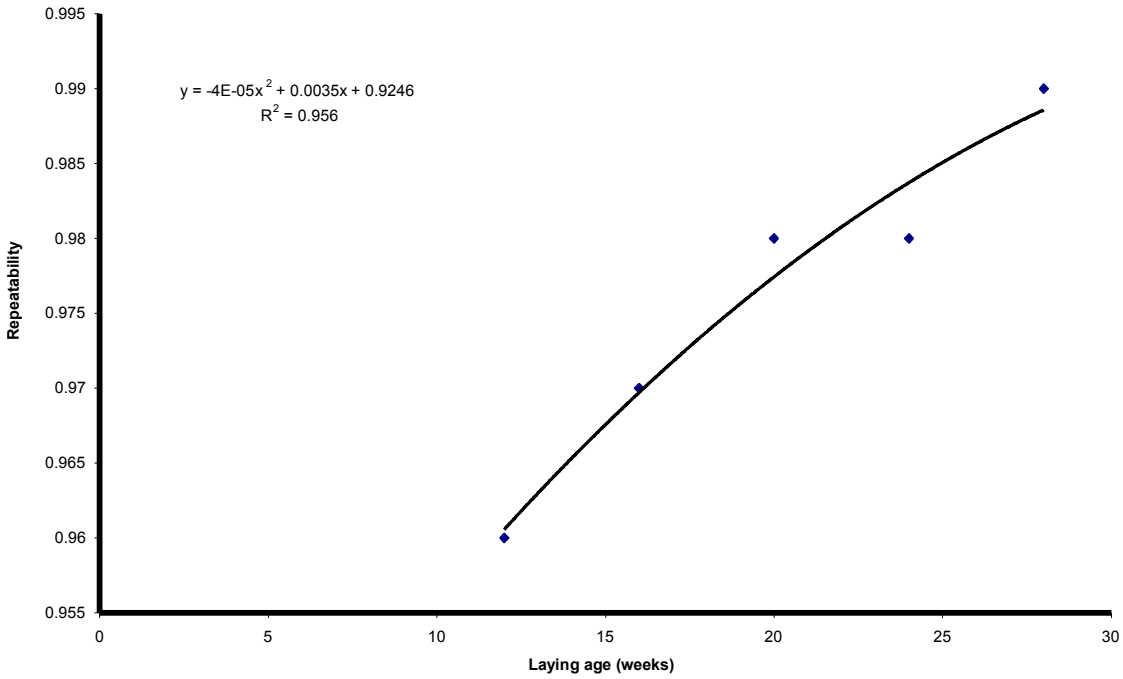


Fig 4.8: Relationship between repeatability of albumen height (mm) and laying age (weeks)

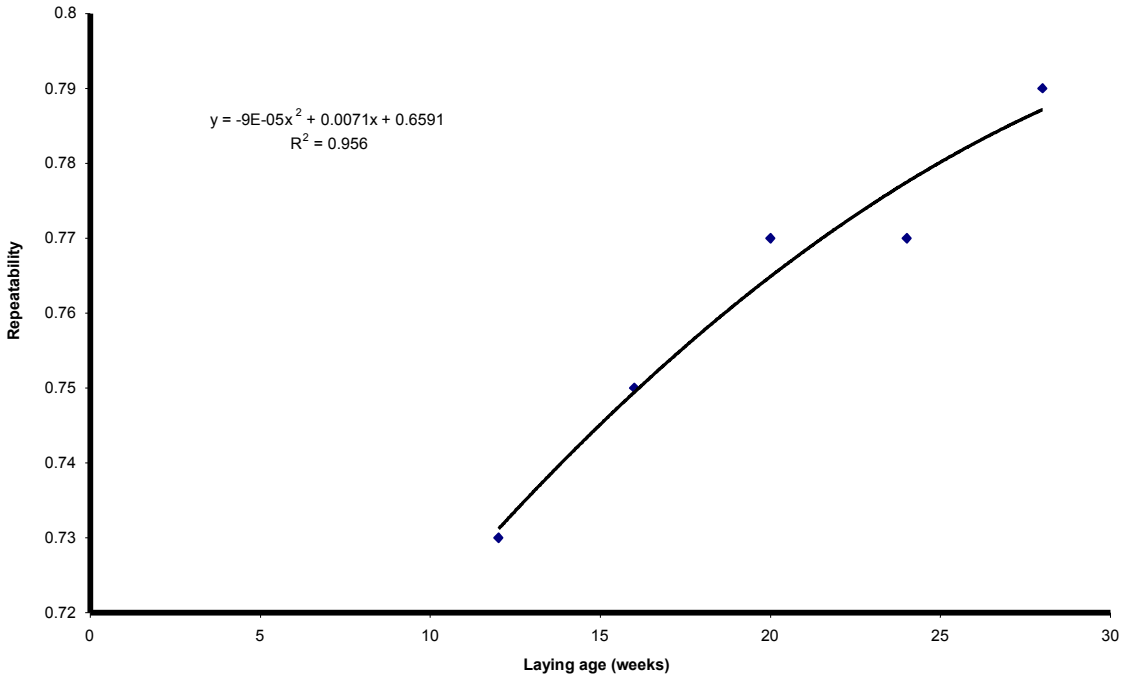


Fig 4.9: Relationship between repeatability of yolk width (mm) and laying age (weeks)

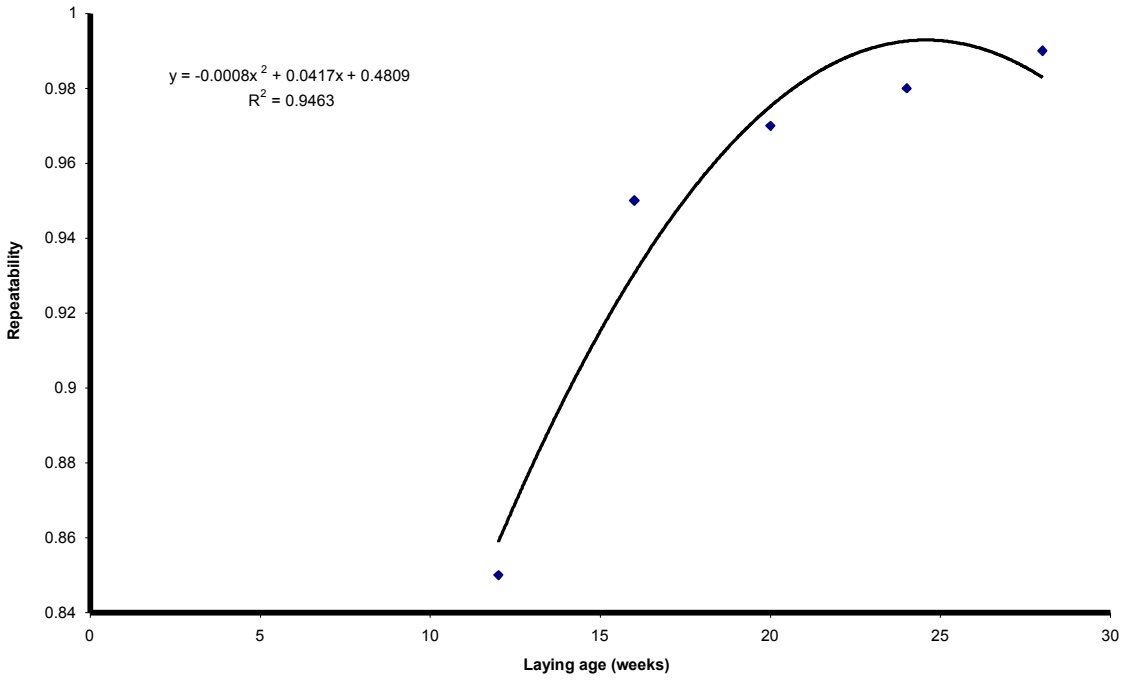


Fig 4.10: Relationship between repeatability of yolk height (mm) and laying age (weeks)

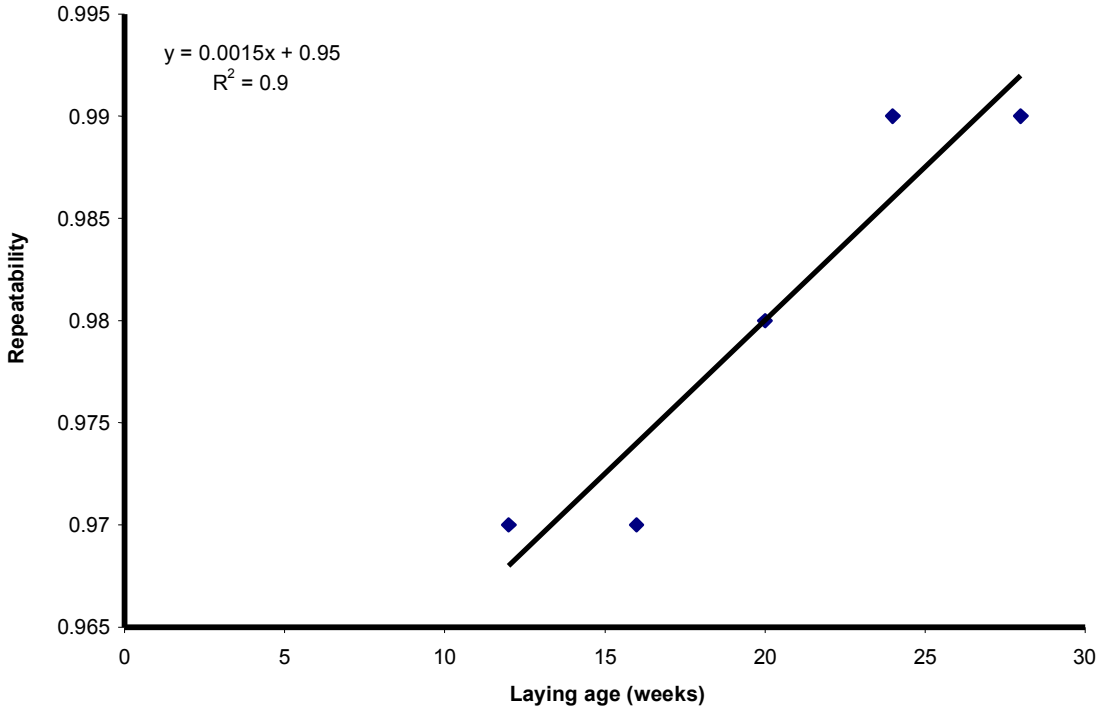


Fig 4.11: Relationship between repeatability of yolk + albumen weight (g) and laying age (weeks)

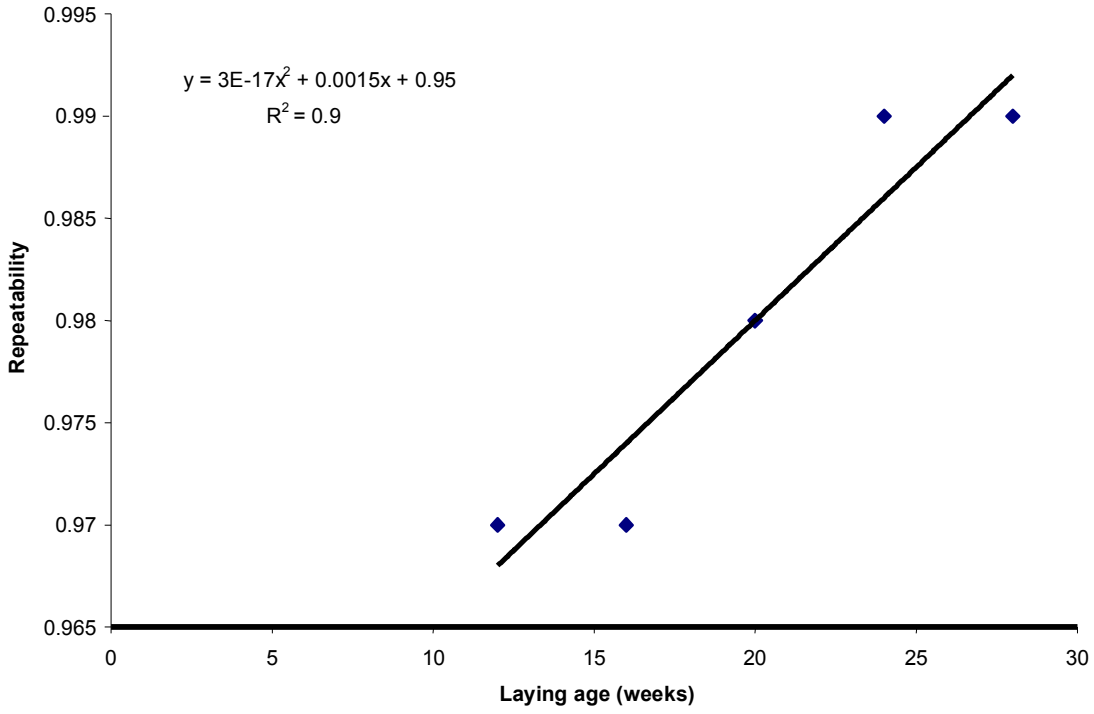


Fig 4.12: Relationship between repeatability of yolk + albumen weight (g) and laying age (weeks)

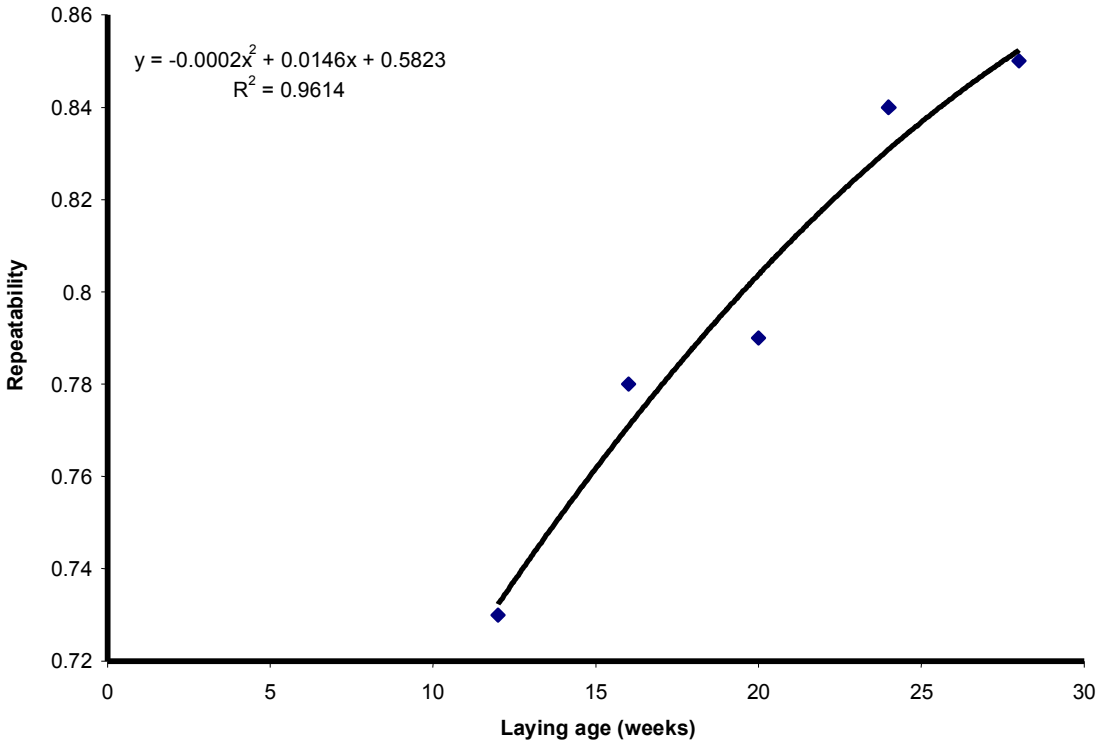


Fig 4.13: Relationship between repeatability of yolk weight (g) and laying age (weeks)

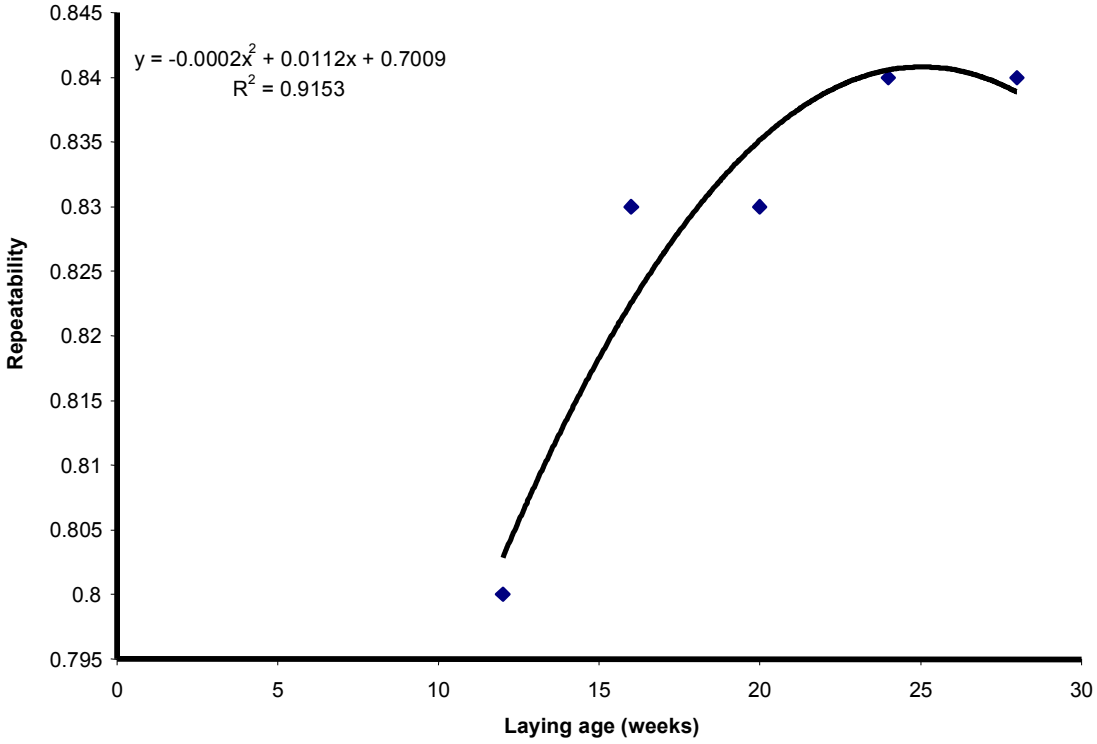


Fig 4.14: Relationship between repeatability of albumen weight (g) and laying age (weeks)

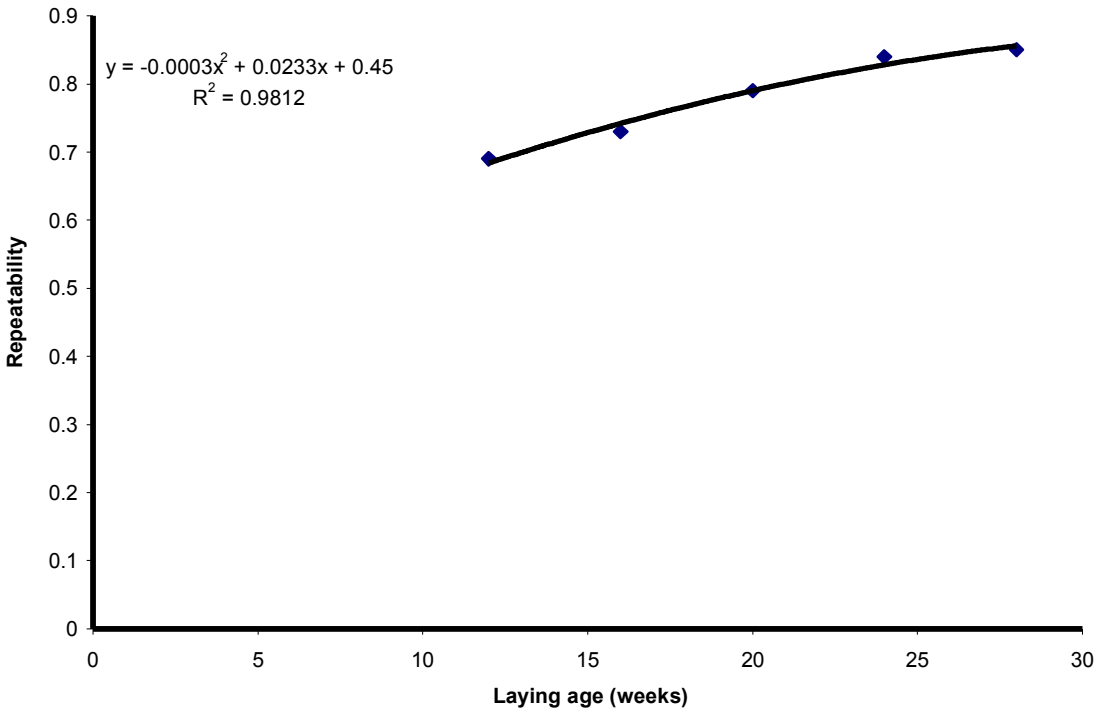


Fig 4.15: Relationship between Repeatability of Shell + membrane weight (g) and laying age (weeks)

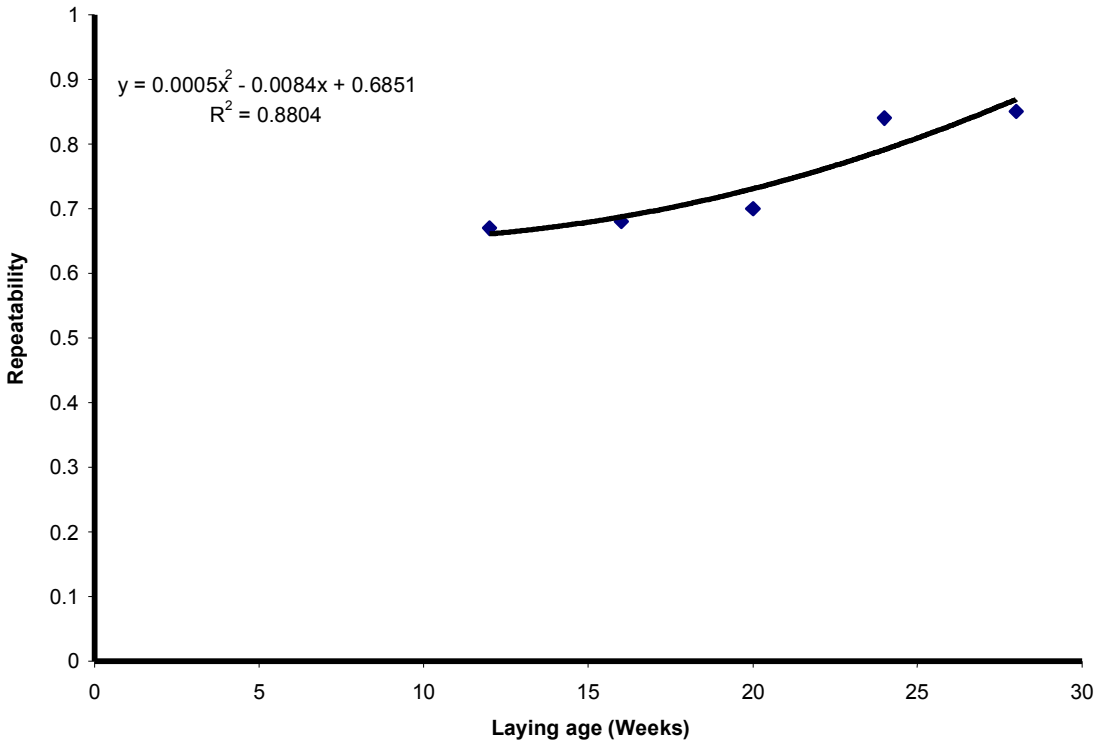


Fig 4.16: Relationship between repeatability of shell thickness (mm) and laying age (weeks)

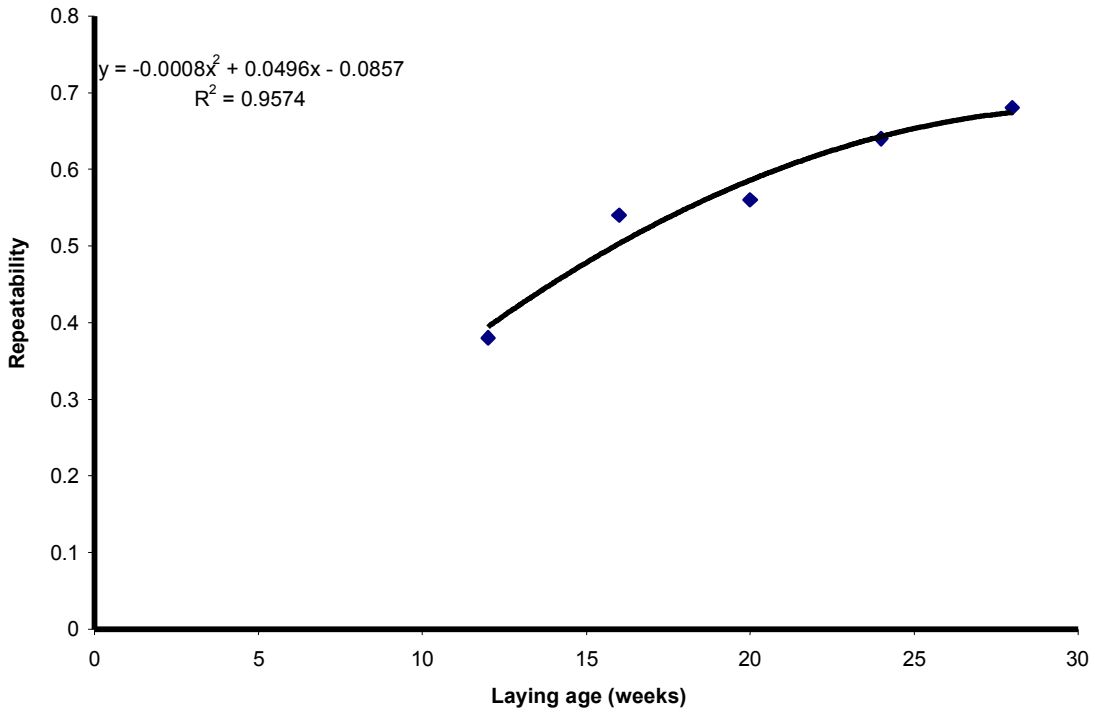


Fig 4.17: Relationship between repeatability of shell membrane thickness (mm) and laying age (weeks)

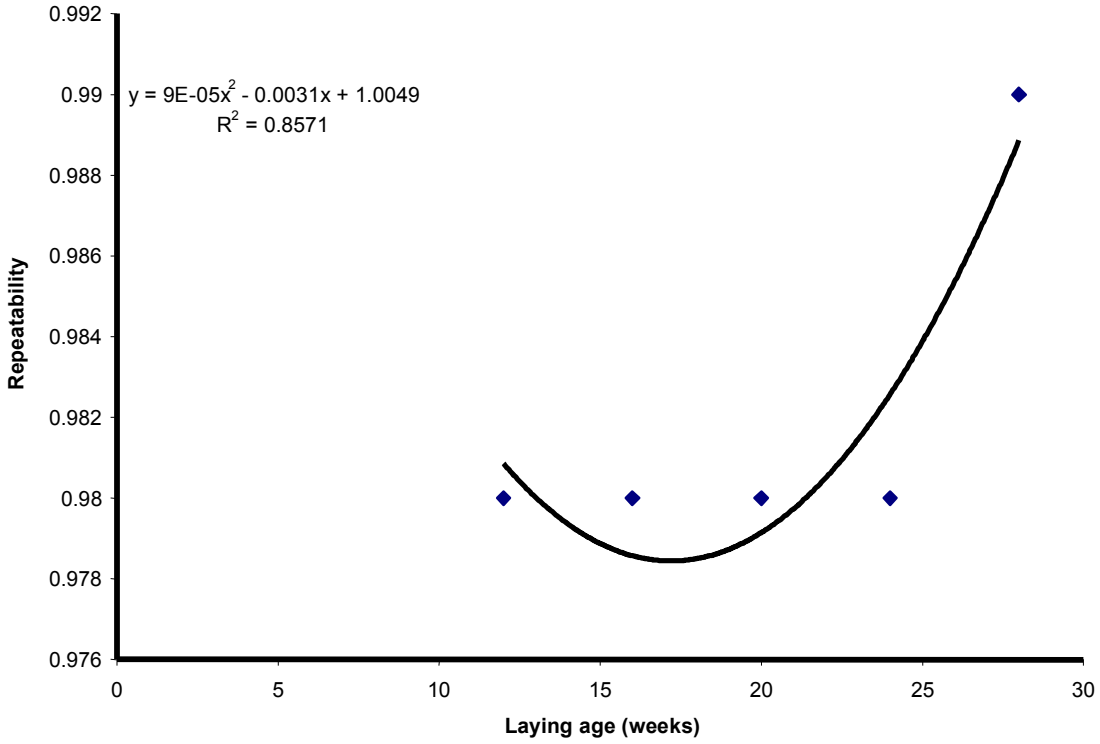


Fig 4.18: Relationship between repeatability of albumen Index and laying age (weeks)

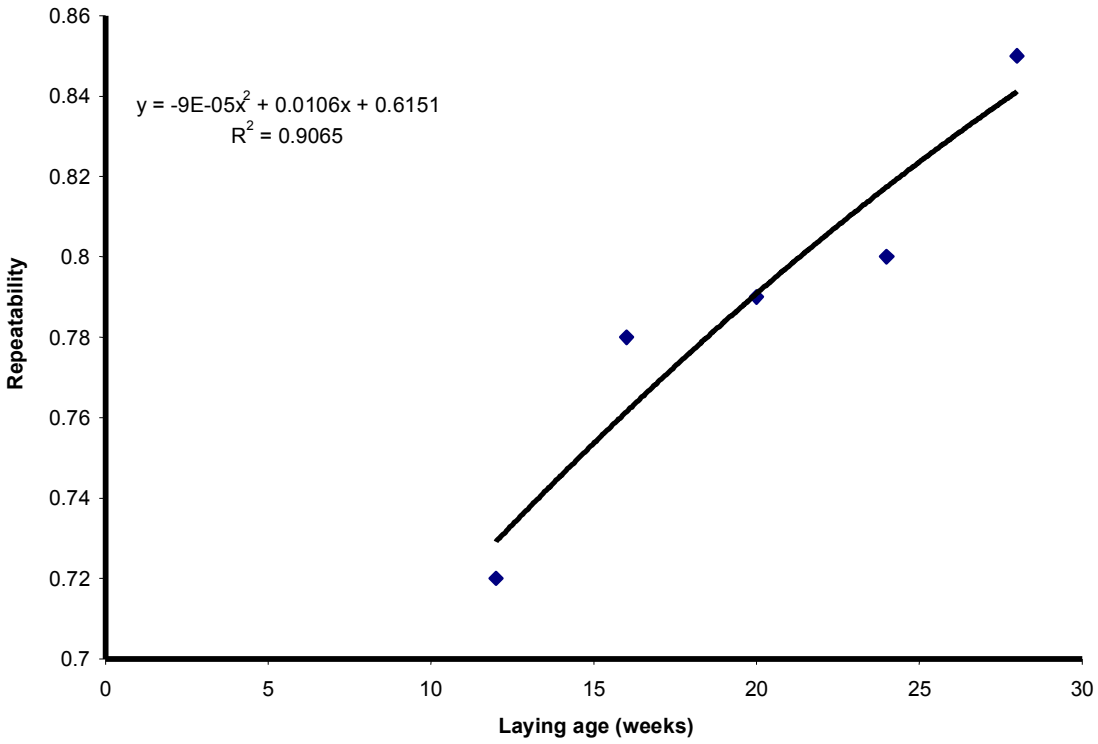


Fig 4.19: Relationship between repeatability of yolk index and laying age (weeks)

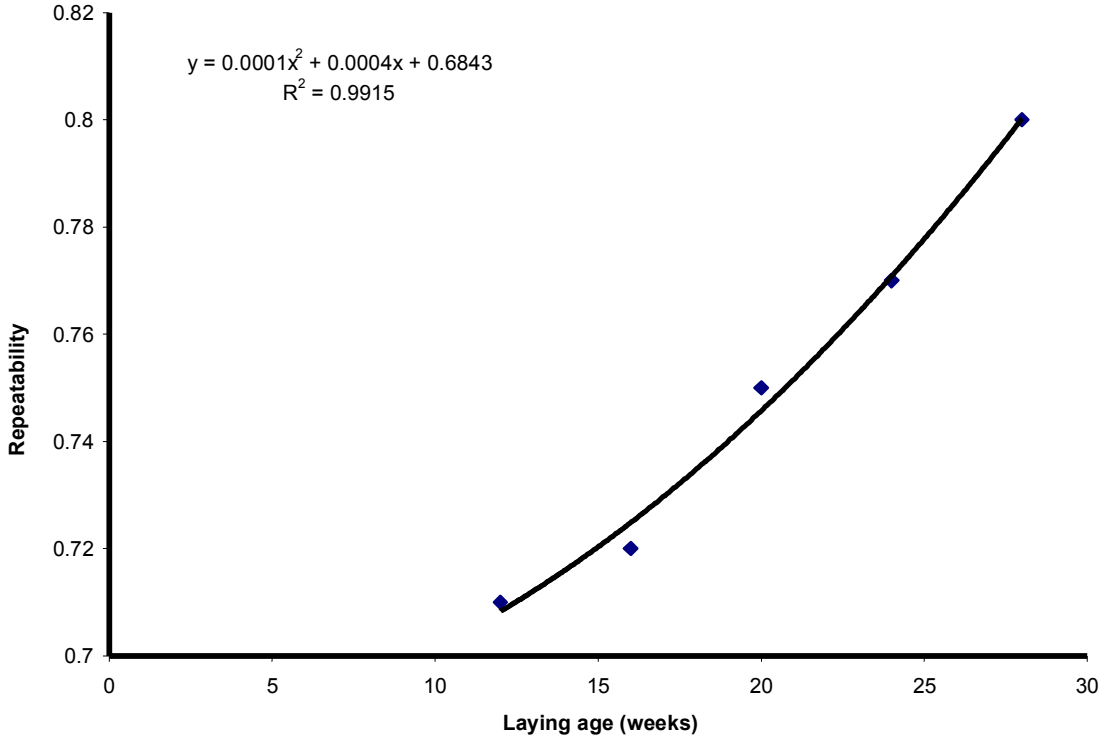


Fig 4.20: Relationship between repeatability of haugh unit and laying age (weeks)

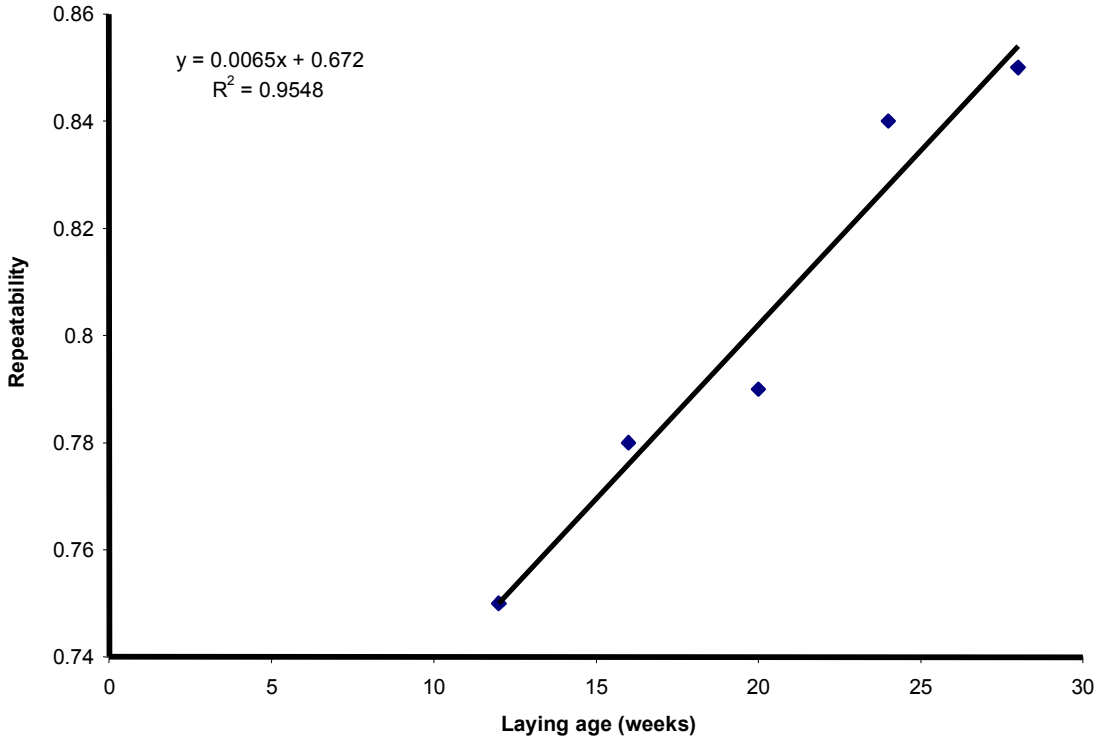


Fig 4.21: Relationship between repeatability of egg index and laying age (weeks)

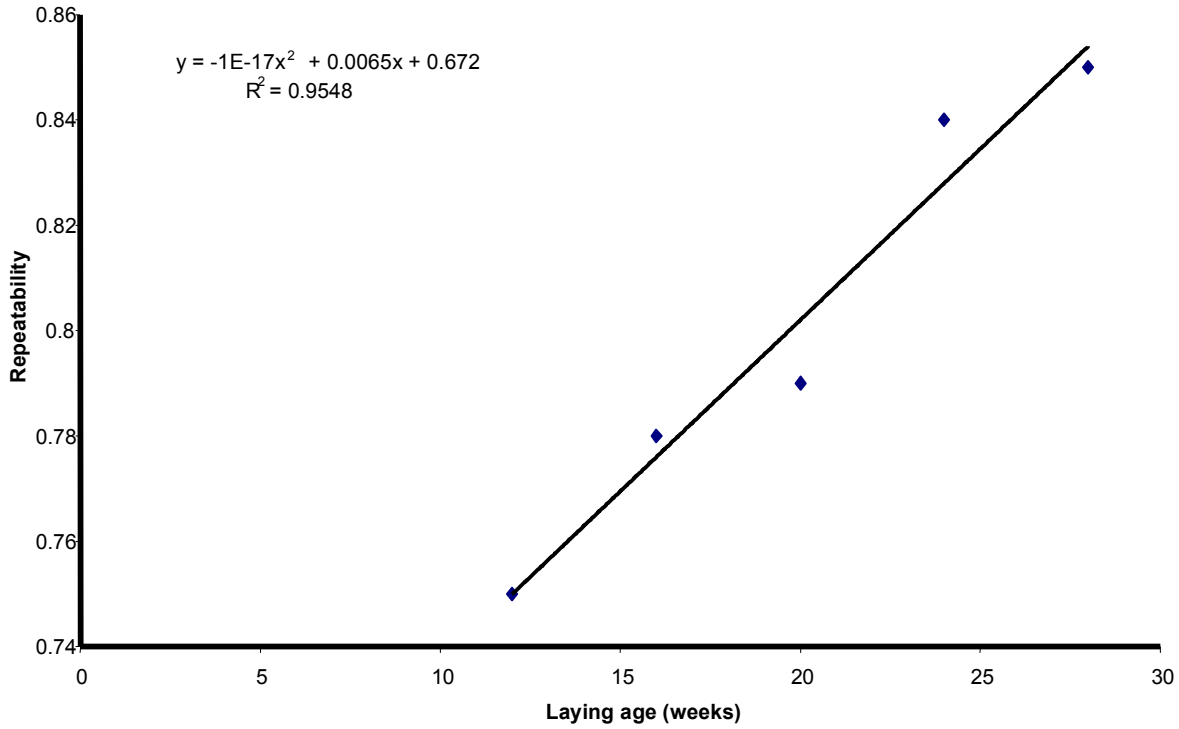


Fig 4.22: Relationship between repeatability of egg index and laying age (weeks)

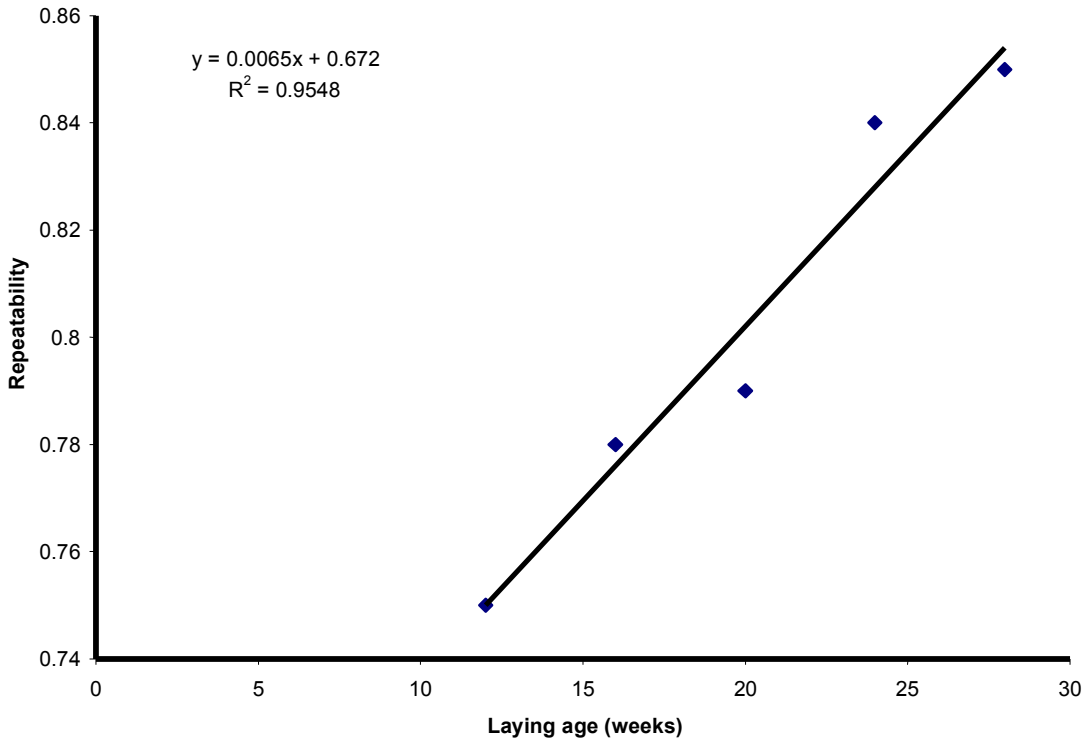


Fig 4.23: Relationship between repeatability of shape index and laying age (weeks)

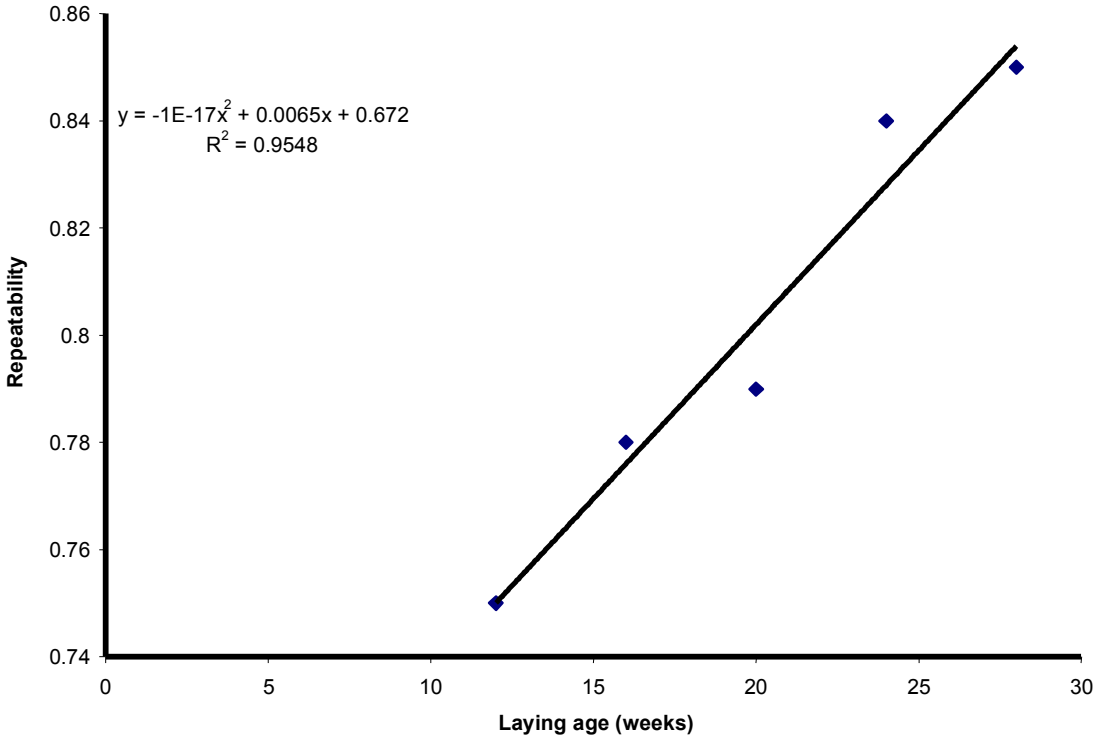


Fig 4.24: Relationship between repeatability of shape index and laying age (weeks)

CHAPTER FIVE

DISCUSSION

5.1 Egg production pattern of Japanese Quails

The average production of 103 eggs in 165 days observed in this study falls within the range reported by Randall (2001) and Przywarona *et al* (2002). They observed that properly managed quail pullets lay approximately 200-300 eggs in 365 days (i.e. 100-150 eggs in 176 days per bird). Egg production however varied widely which could be attributed partly to genetic and non-genetic factors. Ibe and Okonkwo, (1994) had observed that genotype of individual and several non-genetic factors have effect on egg production in birds.

The Japanese quails lay eggs in a good number of clutches. The clutch size of 3 eggs as observed in this study however is lower than production even in the wild. Varghese, (2002) reported that wild Japanese quails lay eggs in small clutch sizes of 5-12 eggs. Thompson, (2001) reported average of 10-12 eggs but indicated that during the dryer periods of the year clutch size tend to be smaller. This may have partly accounted for the small clutch size in the present study since the period of study, December to May, falls within the dry period of the year in this part of the country. To have good number of clutches and to maintain constant egg production of 29-55 batches good management must be practiced.

The pause length of days observed in this study is normal. Quails under good production must skip 1-3days on average (resting period) in order to regain body weight lost as a result of egg production before continuing production (Varyhese, 2002).

However if birds under production in a certain environment are moved to a new one, a prolonged pause length may be observed instead of the normal 1-3 days length (Randall, 2002).

The significant and positive correlation between egg number and clutch size indicates that any improvement in management aimed at increasing clutch size would invariably increase egg number. Positive relationship between egg number and clutch size had been reported by Render *et al.* (1984). On the other hand, egg number would be decreased by increasing the number of clutches, numbers of pauses, days paused and pause length within a given laying period due to its negative correlations with these traits. Negative correlation of this nature had been reported by Nozchev and Kuneue, (1973) and Harms *et al.,* (1982). The implication of the observed result on quail egg production under Zaria environment, would be that the production environment should favour large clutch sizes with smaller number of clutches. This would increase egg number at the rate of 18.84% while number of pauses, days paused and pause length would reduce. This assertion is further buttressed by the R^2 value of 72% for egg number and clutch size, which indicates that clutch size accounted for 72% of the variation in egg number with only 28% of such variation being attributable to other sources. Although, the pause length only accounted for 30% of the total variations in egg number, it is important to note the high rate (-25.91%) at which it can decrease egg number. This has to be checked in order to achieve optimum egg production by the quails. Other characteristics that would decrease egg number are number of clutches, number of pauses and days paused.

The egg production curve of Japanese quails in figure 4.1 indicates that soon after the beginning of lay, production quickly reached 71%. This is a good egg production

pattern for either backyard or large scale production. Production rose sharply and reached a peak of about 86%, in 12 - 17 weeks. The genetic make-up of flock, environmental factors, and resistance to diseases are the major determinants of good egg production. Jacob *et al.* (2003) similarly found that chicken egg production rises sharply after the beginning of production and reaches a peak of about 90%, 6-8 weeks later. Randall, (2001) and Przywarova, (2002) stated that proper cared for quail pullets attain approximately 56.18-84% production in 356 days.

There was a drop in egg production after 17 weeks. Unraveling the cause of sudden drop in egg production requires thorough investigation into the history of the flock. Egg production can be affected by factors such as feed consumption (quality and quantity), water intake, intensity and duration of light received and other environmental influences. University of Florida / Institute of Food Agriculture Science (2003) stated the factors that affect egg production in chicken to be age, resistance to disease, light control, quality of feed, temperature, humidity, molting, condition of the laying house and handling.

5.2 Egg quality characteristics in Japanese quails

The observed significant influence of age on body weight and egg quality traits had also been reported by earlier workers (Yannakopoulos and Tserveni – Gousi, 1986; Chineke, 2001). Changes in body weight and egg quality traits in relation to age have been stated to be due to genetic and non – genetic factors (Ibe and Okonkwo, 1994). As observed by Ferederic (1994), the non – genetic factors are age, maternal effects, feeding, diseases, management and climate while the genetic factors include breed, strain or variety and individual variations in performance. The changes in egg length, albumen

height, yolk height, shell plus membrane weight with age in this study are similar to those observed by Perek and Snapir (1970), Roland (1976) and Hamilton *et al.* (1979) in chickens.

Quail eggs had lower proportions of albumen and higher proportions of yolk, in agreement with the report by Yannakopoulos and Tserveni – Gousi (1986) but the proportions are different from those of chicken (Fleetcher *et al.,* 1983). Similarly quails egg shell qualities as judged by shell thickness and egg shape index are poorer than those of chicken. However, Asmundsen *et al.* (1943) stated that quail eggs have stronger shell membrane than chicken eggs as judged by membrane weight expressed as a proportion of egg weight (2.61% compared with 0.63%).

The observed decrease in egg weight and shell quality characteristics with advancement in age is in agreement with the earlier observations Yannakopoulos and Tserveni – Gousi (1986). In chickens, however, Fletcher *et al.* (1981) reported that egg weight, dry shell weight, deformation and the proportion of yolk increased with increase in laying age. From the observed results, it would appear that quail eggs depreciate in both quality and quantity with advancement in age. It is therefore uneconomical to keep quail hens in production for a long time.

It had been reported that egg shape in chickens is affected by shell thickness (Hammerle, 1969); and since the structure of the shell of quail eggs is similar to that of chickens (Taylor, 1970; Andujar, *et al.,* 1978), close association must also exist between shell thickness and egg shape in quails. Thus the result of this study, implies that eggs with higher shape index have stronger shells. This has been reflected in the significant and positive correlation between egg shape and shell quality as assessed by the shell

thickness. The albumen weight being negatively correlated with egg shape, suggests that heavier eggs have smaller albumen index and large yolk index.

5.3 Repeatability of body weight and egg quality traits in Japanese quails

Repeatability estimates of the various traits measured at 12 and 28 weeks of age for all the traits were high except for shell membrane thickness. The estimates for some of the traits were higher at 28 weeks than at 12-weeks. The magnitude of the repeatability estimate gives an indication of the number of records required to characterize the inherent transmitting ability of an individual. Generally, fewer records per individual are required for traits with high repeatability than for those with lower values. The results in Table 4.8 indicate that fewer records will be required on each hen for all traits except for shell membrane thickness. Similarly, fewer records will be required for all traits at 28 weeks than at 12 weeks.

There is limited information in literature about repeatability of 28 weeks egg quality traits in quails. Whilhemson, (1975) however reported high repeatability estimate of egg quality traits of quails (0.46 - 0.58) which are less than the values found in this present study. In poultry, similar repeatability estimates had been reported for egg weight, shell thickness and haugh unit for 22 - 30 weeks old (Okonkwo and Ibe, 1994; Ibe, 1984) and for 22 - 30 weeks, 32 week and 50 - 57 week old commercial layers, (Ayorinde and Sado, 1988). Repeatability estimates for egg weight in this study are similar to the values reported by Lerner and Cruden (1951) and Akinokun and Dettmers (1977) for Nigerian local chickens, although lower values were obtained by Scheinberg *et al.* (1953), Ibe (1984), and Goodman (1965) in exotic strains. The repeatability estimates for all the traits obtained in this study are higher than those reported by Okonkwo and Ibe (1994) and Ibe (1984). The repeatability estimate for haugh unit in this study is similar to

that reported by Godfrey *et al*. (1954) and Dickerson and Lamoreux (1954). The repeatability coefficient for shape index also falls within the range of 0.58 - 0.68 reported by Kotaiah *et al*. (1974), Ayorinde and Sado (1988). However, King and Hall (1955) had reported repeatability coefficient of shape index of 0.75 - 0.85 for quail eggs. Sooncharenying and Edward (1989) reported repeatability coefficients of 0.80, 0.94 and 0.85 for egg weight, shell weight and shell thickness, respectively. The repeatability estimate obtained for shell thickness in this study agrees with this report, while that of egg weight was lower.

The discrepancies in the estimates of repeatability probably reflect the differences in species, breeds and ages of birds used, and the various environmental factors that affected the experimental animals. For instance, Scheinberg *et al.* (1953) obtained three different repeatability estimates for yolk weight in chickens of different genetic backgrounds, while King and Hall (1955) reported increase in repeatability values as laying progressed.

The expected genetic gains per generation of selection for body weight and egg quality traits at 12,16,20,24 and 28 weeks of age for all traits indicated that relative genetic gain increased with increase in number of records on each individuals. Caceres (1967) reported that there was consistent gain in part period and annual number of eggs in a population when selection was carried out strictly on number of eggs in part period. However, the rate of increase was smaller, for traits with high repeatability values. By considering the additional cost of collecting more records and the greater expected genetic gain per generation due to shortened generation interval, the optimum number of eggs per hen, that would be required to adequately characterize its transmitting ability in

the various traits at 12 weeks are 4 (for egg weight, egg length, egg breadth, albumen width, albumen height, yolk width, yolk height, yolk + albumen weight, yolk weight, albumen weight, shell + membrane weight, shell + membrane thickness shell thickness, shell membrane thickness, and haugh unit and 8 (for albumen index, yolk index, egg index and shape index). With these numbers, greater genetic gains of the following magnitudes, relative to the gain using only one egg, would be realized: 6.03-8.56% for 4 records per traits and 22.85-26.30% for the 8 records per traits. However, there will be 5.82 – 10.07% for (egg weight, egg length, egg breadth, albumen width, albumen height, yolk width, yolk height, yolk plus albumen weight, yolk weight, albumen weight, shell plus membrane weight, shell membrane thickness, shell thickness, shell membrane thickness and haugh unit) and 22.49 – 26.28% (for albumen index, yolk index, egg index and shape index) less genetic gain using these numbers than using 280 eggs which is the expected optimum egg production of a well – managed quail pullet in a year.

At 28 weeks, 3 eggs per pullet (for egg weight, egg length, egg breadth, albumen width, albumen height, yolk width, yolk height, yolk plus albumen weight, yolk weight, albumen weight, shell plus membrane weight, shell plus membrane thickness, shell thickness, shell membrane thickness and haugh unit) and 6 eggs per pullet (for albumen index, yolk index, egg index and shape index) are considered adequate. These are expected to result in 6.37-7.82% greater genetic gain than measuring one egg per quail and 24.10-25.30%, less gain than measuring 280 eggs per quail.

5.4 The relationship between laying age and repeatability of egg quality traits in Japanese quails

The high repeatability estimates ranging from 0.70-0.99, of the measured traits in this study agrees with the observation of Meritt *et al.* (1960) Sooncharengiang and

Edward, (1989) with the exception of shell thickness which was 0.67 at 12 weeks and 0.68 at 16 weeks and shell membrane thickness at 12,16,20,24 and 28 weeks with values of 0.33, 0.54, 0.56, 0.56 and 0.58, respectively. The implication of the high repeatability values is that fewer records will be required to characterize the inherent transmitting ability of individuals. This leads to some savings in the cost of collecting additional data.

From the comparative efficiencies expressed in the study, relationship between laying age and the repeatability of egg length, yolk and albumen weight, egg index and shape index can be effectively predicted using both liner and quadratic models. However, the quadratic model was better for predicting the relationship between laying age and repeatability of body weight, egg weight, egg breadth, albumen width, albumen height, yolk height, yolk width, yolk, weight, albumen weight, shell plus membrane weight, shell thickness, shell membrane thickness, albumen index, yolk index and haugh unit.

From the regression of the better-fitted models, as presented in Figures 4.2-4.2.4 repeatability of egg length, yolk and albumen weight, egg index and shape index increased linearly with laying age. The rates of increase were 0.0025, 0.0015, 0.0065 and 0.0065 per week, respectively. However, the repeatability of body weight, egg weight, egg breadth, albumen width, albumen width, albumen weight, shell plus membrane weight, shell thickness, shell membrane thickness, albumen index, yolk index and haugh unit, on age of birds showed curvilinear relationships. Thus, indicating that there are ages at which repeatability values of some of these traits are maximum. This implies that it would be at these ages that the prediction of the highest transmitting ability of individuals for the traits would be made. This age was 28 weeks for repeatability of body weight, egg weight, egg breadth, albumen width, albumen height, yolk width, yolk weight, shell

membrane weight, shell thickness, shell membrane thickness, albumen index, yolk index and haugh unit, respectively; and 24 weeks for yolk height and albumen weight, respectively.

CHAPTER SIX

CONCLUSIONS

The high relationship between egg number and clutch size in Japanese quails, suggests that clutch size can be used as a yardstick for measuring egg production in a quail production industry.

The results of this study had shown that egg quality characteristics in Japanese quails are influenced by age, body weight and egg weight of the laying hens. Similarly egg shape can be used as a criterion for measuring shell strength under practical conditions.

The comparative efficiency of the two models for estimating the relationship amongst age, body weight and egg quality traits showed that quadratic model was a better estimator than linear model.

At 12 weeks of age, four egg per hen were considered adequate for characterizing the pullets for inherent transmitting ability of egg traits while 8 eggs were required for the egg indices.

The general increase in repeatability of each trait with age indicates that fewer records would be required to characterize the inherent producing ability of each hen for egg traits as laying age progressed to 28 weeks of age.

REFERENCES

Adeogun I.O. and Adeoye A.A. (2004). Heritabilities and phenotypic correlations of growth performance traits in Japanese quails. Livestock Research for Rural Development 16 (12) pp 1-7.

Aggrey S.E and Cheng K.M. (1994). Animal model analysis of genetic (co) variances for growth traits in Japanese quail. Poultry Science (Medline). 73: 1822-1828.

Ajaykumar, 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. Department of Animal Breeding and Genetics, Bihar Veterinary College, Patna. Indian Vet. J, 77:325-327.

Akinokun, O and Dettmers, A. (1977). Repeatability of egg production and egg weight of exotic and local breeds and strains of chickens. *Nigeria Journal of Genetics 1:96-100.*

Akpa, G.N; O.E. Asiribo, O.O. Oni, J.P. Alawa, N.I. Dim; O.A. Osinowo and B.Y. Abubakar (2002). Milk production by Agrospastoral Red Sokoto goats in Nigeria. *Tropical Animal Health and Production, 34 (6): 525-533.*

Altan, O. and Oguz, I. (1996). Effects of heat stress on some egg characteristics and acid-base balance in two lines of Japanese quail, unselected and selected for four – week body weight. Turkish Journal of Veterinary and Animal. Science 20: 211 – 214.

Altan, O. and Oguz, I. (1997). Effect of oviposition time on some egg characteristics in lines of Japanese quail (*Coturnix coturnix japonica),* unselected and selected for four – week body weight. Archiv fur Getugelkunde 61:218-220.

Altan, O., Oguz, I and Akbas, Y. (1998). Effects of selection for high body weight and age of hen on egg characteristics in Japanese quail (*Coturnix coturnix japonica).* Turkish Journal of Veterinary and Animal Sciences 22: 467-473.

Andujar, M.M; Varela, G and Navarro, M.P (1978). Dieldrin, Ca and P Balance, and characteristics of the egg in the quail (*coturnix japonica)*. Poultry Science, 57: 596-602.

Anthony, N.B; Wall C.W.; Emmerson, D.A, Bacon W.L and Nesfor K.E. (1993). Divergent selection for body weight and yolk precursor in *coturnix japonica*. 9 Evaluation of traits associated with onset of sexual maturity. Poultry Science. 72: 2019-2029.

Arrington, K.L., Toye, A.A and Aruleba, T.P. (1988). Association between body weight and some egg production traits in a strain of commercial layers. Nigeria Journal Animal of Production. 21:119-125.

Arrington, L.C., Abplanalp and Wilson W.O. (1962). Experimental modification of the laying pattern in Japanese quail. British Poultry Science Vol. (3) 105 – 113.

Asmundsen, V.S., Baker, G.A. and Emlen, J.T. (1943) Certain relations between the parts of birds eggs. Turkish Journal of Poultry Science 2 (60): 34 – 44.

Ayorinde, K.I and Sado, C. (1988). Repeatability of egg weight and egg shape of an exotic commercial layer in Nigeria. Nigeria Journal of Animal production 15:157-160.

Ayorinde, K.L; Atteh, J.O and Joseph, K. (1994). Pre-and Post hatch growth of Nigerian indigenous guinea fowl as influenced by egg size and hatch weight. Nigeria Journal Animal of Production 15:59-65.

Bannerman, D.A. (1952). The Birds of West and Equatorial Africa. Oliver and Boyd Ltd, London 1:331 – 487.

Baumgartner J. (1993). Japanese quail production, breeding and genetics: Proceedings of the 10th International symposium on current problems of Avian Genetics, Nitra, solvakia pp 101-103.

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

Becker, W.A. (1984). Manual of Quantitative Genetics, 44th ed. Academic Enterprises, Washington, U.S.A.

Bonerman, K.N, (1980). Dietary constraints on nitrogen retention. Butterworth and company publishers Limited, London.

Buttery, P. J and Lindsay D.B. (1980). Protein deposition in animals. Butterworth and company publishers, London, 151-160.

Button, J.A. (1967). The birds of Ilaro. Nigeria Ornithology Society Bulletin 4:17.

Caceres, O. (1967). Accelerated selection for hen housed egg production and correlated responses in white leghorn (Gallus domestic) Iowa State University, U.S.A Pp. 71.

Cheng and Kunever, (1990), Mutation and major variants in Japanese quail. Craw & R.D. Published. New York. 48: 333-362.

Chineke, C.A. (2001). Interrelationships existing between body weight and egg production traits in Olympia black layers. *Nigeria Journal of Animal Production 28 (1) 1-8.*

Combs, G.F. and G.L. Romoser (1955). Studies on the Melhionine requirements of growing chickens. Poultry science 34: 1225.

Clauer, P.J., Greaser, G.L., Hulet, R.M. and Harper, J.K (2002). Bobwhite quail productions. Pennsylvania game Breeders Association. Susquehanna design and printing. Millersburg, PA 17061.

Dickerson, G.E and Lamoreux, W.F. (1954). Repeatability and heritability estimates of albumen quality in white leghorns *Poultry Science 33:1053 (Abstr.)*

Dunnington, E.A, and Sielgel P.B. (1984). Age and body weight at sexual maturity in female white leghorn chickens. Poultry Science. 63: 828 – 830.

Duplessis, P.H.S. and Erasmus, J. (1972). The relationship between egg production, egg weight and body weight in laying hens. *World Poultry Science Journal 28 (2): 73-85.*

Eitan, Y; and Soller M. (2001). Effect of photoperiod and quantitative feed restriction in a broiler strain of semen production in males: A genetic hypothesis. Poultry Science. 80: 1397-1405.

El – Ibiary, H.M., Godfrey, E. F and Shaffner, C.S. (1966). Growth and reproduction of quails. Poultry Sci. 45: 463-469.

Elgood, J.H. (1964). Provisional checklist of the birds of Nigeria. Nigerian Ornithology Society Bulletin 1-13.

Erasmus, G.J., Delonge, A.O., Delport, G.J. and Oliver, J.J. (1972). Presence of in Breeding: a selection experiment with Animals South African. Journal of Animal Science. 21:190-220.

Fairbairn, W.A (1952). Some game birds of west Africa. Oliver and Boyd, London. 33:47.

Farnsworth, G.M and Nordskog, A.W. (1955). Breeding for egg quality 3. Genetics difference is shell characteristics and other egg quality factors. *Poultry Science.* 3:16-26.

Federic, C.D. (1994). Factors that influence egg production. Animal science Department Institute of Food and Agricultural Science, University of Florida. Pp. 16-81.

Flectcher D.L., Britton W.M., Rahn, A.P and Savage, S.I. (1981). The influence of layer flock age on egg component yields and solids content Poultry Science.60:983-987.

Fletcher D.L., Britton, W.M., Pesti, G.M., Rahn, A.P and Savage, S.I. (1983). The relationship of layer flock age and egg weight on egg components yields and solids content. Poultry Science. 62: 1800-1805.

Friedman, M. (1977). Nutritional improvement of food and feed protein. Plenum Press: New York London.

George, L.G. (2002) Basic production and management of quails. Penn. State College of Agricultural Science Research pp 1-16.

Godfrey, G.F. Goodman, B.L. and Newell, G.W. (1954). Repeatability and heritability estimates of albumen quality, *Poultry Science 37:1056(Abstract.)*.

Goodman, B.L. (1965). Repeatability of egg quality traits in *coturnix* quails P*oultry Science 44:1338-1339*.

Hamilton, R.M.G and Voisey R.W. (1964). Methods and factors that affect the measurement of egg shell quality. Poultry Science. 61:2022-2059

Hamilton, R.M.G. (1978). Observation on the changes in physical characteristics that influence egg shell quality in ten strains of white leghorns. Poultry Science., 57: 1192-1197.

Hamilton, R.M.G.; Hollands, K.G; Voisey, P.W. and Grunder, A.A. (1979). Relationship between egg shell quality and shell breakage in the field – a review. World. Poultry Science. Journal; 35: 177-190.

Hammerle, J.R. (1969). An engineering appraisal of egg shell strength evaluation techniques Poultry Science. 48: 1708-1717.

Harms, R.H., Junquioera, O.M. and Wilson, H.R. (1983). Specific gravity of turkey and bobwhite quail eggs as influence by time of ovipositor Poultry Science, 62: 1325-1326.

Harms, R.H. Junquioera, O.M. and Wilson, H.R. (1996). Bodwhite quails eggs and influence by time Oriposition. Poultry Science. 62:1325-1326.

Harms, R.H., Costa, T.P and Miles, R.D. (1982). Daily feed intake and performance of laying hens grouped according to body weight Poultry Science. 61 (60) 1021.

Haruna, E.S; Musa, U; Lombin, L.H; Fat P.B; Shamaki, P.D; Okweole P.A and Molokwo J.O (1997). Introduction of quail production in Nigeria. Nigeria Veterinary Journal. 18: 104-105.

Harvey, W.R. (1987). Mixed model least-squares and maximum likelihood computer programme (LSMLMW) Ohia State University.

Haugh, R.R. (1937). The haugh unit for measuring egg quality. United State Poultry Magazine 43: 552-555.

Hocking, P.M. (1993). Effects of body weight sexual maturity and the degree and age of restriction during rearing on the Ovarian foolicular hierarchy of broiler breeder females Br. Poult. Sci. 34: 793-801.

Hutt, F.B., (1964). Animal Genetics. The New York state college of Agriculture at Cornell University, Ronald Press Company. New York. 321-343.

Huxley J.S. (1932). Problems of relative growth. Craw R.D. Pub. New York, 12: 1-134.

Ibe, S.N. (1984) Repeatability of egg quality traits in white leghorn chickens. *Nigeria Journal of Genetic 5:44-49.*

Ibe, S.N and Okonkwo, J.C. (1994). Relationship between laying age and repeatability of egg quality traits. Nigeria. Journal of Animal Production 21: 66-70.

Itoh, T., Kobayashi, S., Sugawara, H and Adachi, S. (1981). Some physico chemical changes in quail egg white during storage. Poultry Science, 60: 1245-1249.

Itoh, T., Sugawara, H and Adachi, S. (1978). Comparative chemical studies on the quail *(Coturnix coturnix japonica)* egg ovalbumin. Comparative Biochemistry and Physiology, 65B: 563-566.

Itoh, T., Sugawara, H and Adachi, S. (1979). Comparative chemical studies on the quail *(Coturnix coturnix japonica)* egg Ovotransferrin. Comparative Biochemistry and physiology, 62B: 41-44.

Itoh, T., Sugawara, H and Adachi, S. (1980). Some properties of the Japanese quail *(Coturnix coturnix japonica)* egg Ovomocoid Comparative Biochemistry and physiology, 65B: 563-566.

Jacob, H.R., Wilson, H.R., Miles, R.D., Butcher, G.D. and Malher[2] F.B. (2003). Factors affecting egg production in background chicken flocks[1]. Animal Sc. Department florida cooperative Ext. Serv. Inst. of food and Agric. Sc. Univer. of florida file: // A: factors % 20 affecting % 20 egg % of production htm.

Jull, M.A. (1924). Egg weight in relation to production. Part 1. The relationship of the weights of the parts of the egg to the total egg weight *Poultry Science, 3: 77-88.*

Katanbat, M.N., Sielgel, P.B. and E.A. Dunington (1988). Organ growth of selected lines of chickens and their first filial crosses to a common body and age. Theoretical and Applied Genetics 76: 540-544.

King, S. C and Hall, G.O. (1955). Egg quality studies at the New York random `sample test. Poultry Science. 34: 799-809.

Kosin, I.L., Abplanalp, H., Gutters 2, J and Carrier, J.S., (1952). Influence of egg size on subsequent early growths of the chick. Poultry Science. 51: 247-255.

Kotaiah, I., Mohapatra, S.C., Anjanejulu, P.S and Ayyagi, V.B. (1974). Heritability estimates for some egg quality traits in chicken. Indian Poultry Gazette 60: 65-71.

Laird A.K. (1965). Dynamic of relation growth. London British Journal of Nutrition. 29: 249-263.

Lasley, J.F. (1968). Genetics livestock improvement. 3rd ed; prentice – Hall Inc, New Jersey.

Lerner, I.M. and Cruden, D. (1951). The heritability and repeatability of egg weight. The advantages of mass selection an early measurements. *Poultry Science 30:34-1.*

Lilja, C. (1983). A comparative study of Post natal growth and organ development in some species of birds. British Journal of Nutrition 47: 217-219.

Lush, J.L. (1945). Animal Breeding Plans. 3rd ed. Iowa State Colleges Press Ames, Iowa.

Marks, H.L., and Kinney, T.B. Jr. (1964). Estimates of some genetic parameters in *coturnix* quail. Poultry. Science. 43: 1338 (Abstract).

Marks, H.L., (1979). Changes in unselected traits accompanying long-term selection for four-week body weight in Japanese quail. Poultry Science 58:269-274.

Marks, H.L., (1991). Divergent selection for growth in Japanese quail under split and complete nutritional environments for genetic and correlated response from generations 12 to 23. Poultry Science. 70: 453: 462.

Mentis, M.T. and Bigaike R.C. (1980). Breeding social behaviour and management of grey – Winged Francolinus, and red-winged from Colins, Francolinus Lexillanti Southern African Journal Wild life Research 10:33-139.

Merritt, E.S; Gowe, R.S. and Pelletier, J.R. (1960). The productive performance of geese in their first and second year. *Poultry Science 39: 1008-1009.*

Michaska, E. (1992). Genetic parameters of body weight and shank length of Japanese quails from four lines over 3 generations. Animal science papers and Reports Polish Academy of Science, Institute of Genetics and Animal Breeding, Jastrezebeic, 10:27-34.

Minvielle, F. (1998). Genetics and breeding of Japanese quail for production around the world. In: proceeding of the 6th Asia pacific poultry congress, Nagoya, Japanese, pp. 122-127.

Nestor, K.E. (1985). Genetics of growth and reproduction in the turkey. 10 Tandem selection for increased body weight and egg production. Poultry. Science. 64: 2221-2222.

Nitsan, Z., Dunnington, E.A. and P.B. Sieldgel (1994). Organ growth and digestive enzyme level to fifteen days of age in lines of chickens differing in body weight Poultry Science. 70: 2040-2048.

Nozchev, S and Kuneuer, K. (1973). Correlation between egg production and some production characteristics in white leghorn hens. A.B.A 41 (7): 367.

NVRI (1990). Manual of Quail Production and Health Management. Poultry Series No. 2, page of 7.

NVRI, (1996). A Manual of Quail Production and Health. Poultry Series No. 1, page of 690.

Okonkwo, J. C and Ibe S.N. (1994). Repeatability of egg number and egg quality traits in commercial pullets Nigeria Journal of Animal production 21:1-30.

Olubajo, F.A (1976). Production of meat from ruminant animals. Nigeria. Journal. of Animal Production. 3 (1): 18-27.

Oluyemi, J. A and F.A. Robert (1985). Poultry production in warm wet climate. Macmillan. Publication Limited, London, 29-40pp.

Onyenekwe, P.C. (1988). Biochemical studies on the meat quality and digestive enzymes of Francolinus Bicalcaratus. Unpublished M.Sc thesis, department of Biochemistry of Ahmadu Bello University, Zaria 50: 65pp.

Orgu, S.O. (1983) Estimation of repeatability of egg number and egg weight of local chicken and their crosses with parent stock of Gold-Link. B.Sc Thesis, University of Nigeria, Nsukka, 25 pg.

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

Padgett, C.S and W.D Ivey (1959). Gonadal histogenesis in *coturnix quail* Journal Alabama Academy Science 31: 101-102.

Padgett, C.S and W.D. Ivey (1960). The normal enbroylosy of the *coturnix quail Ana.* Rec. 137:1-11.

Pand, B. and Singh, R.P. (1992). Developments in processing quail. World's Poultry Science. Journal 46:219-234.

Paul, A.T. and Sarker, J.S. (1999). Bobwhite production. Turkish Poultry of Journal 32: 73-146.

Perek, M and Snapir, N. (1970). Interrelationships between shell quality and egg production and egg shell weights in white leghorn and white rock hens. British Poultry Science, 11:133-145.

Piano, J. Okonmoto, S; Kobayashi, S and Wada, Y. (2004). Purebred and crossbred performance from a Japanese quail body size. graduate school of Agricultural. Uni. Animal. Dol. PDF Res. Science. 53.

Przywarona, A; Parametru, H and Snasky, U. (2002). Evaluation of egg production efficiency of laying lines of Japanese quail (*(Coturnix coturnix japonica)* Mendel University of agriculture and forestry Brno. Pp. 110.

Randal, Maurice, (2002). Raising Japanese quail. Department of Pri. Industries series NSR: Newsouth Wales Govt's Portal. 1-8pp.

Render, J.A. (1984). Egg characteristics and production efficiency of dwarf white leghorn hens divergently selected for body weight. Poultry Science: 63 (2): 214.

Render, J.A; Mc Daniel, G.R and Mc Quire, J.A. (1984): Egg characteristics and production efficiency of dwarf white leghorn hens divergently selected for body weight. *Poultry Science. 63 (2): 214.*

Resende, R.O., Martins E. N George P.C., Paiva E; Conti A.C.M., Santos A.I., Sakaguti,

E.S., and Murakami A.E. (2005). Variance components for body weight in Japanese quails (*Coturnix coturnic japonica*). *Revista Brasiltera de Ciencia Avicola.* Vol. 7 No. 1.

Ricklefs, R.F., and Marks, H.L. (1993). Egg characteristics on lines of Japanese quail selected for four-week body mass. Poultry Science, 62: 1330-1332.

Risse, J. (1980) Guinea fowl and quail as poultry meat: In Mead G.C and Freeman B.M. (Eds.) Meat Quality in Poultry and Game Birds, *Edinburgh, British Poultry Science 193:197*.

Roland, D.A., (1976). Recent developments in egg shell quality feedstuff, in chickens. 48 (29): 31 – 32.

Sa'adeh, H.K. Craig, J.U. Smith, L.J and Wearden, S. (1968). Effectiveness of alternating

breeding systems for increasing rate of egg production in chickens, *Poultry Science 47:1057-1072.*

Saatei, M, Dewi, I.A.P, Aksoy, A. Kirmizibayrak, T., (2002). Estimation of genetic parameter for weekly live weight in one sire and dam pedigree recorded Japanese quail. In 70 world congress of Genetic Applied to Livestock Production, Paris, France. Pp 20.

Sato, K; Ida, N and Ino, T. (1989a). genetic parameters of egg characteristics in Japanese quail. Jikken Dobutsu 38: 55- 59.

Scheinberg; S.L., Ward, H and Nordskog, A.W., (1953). Breeding for egg quality 1. Heritability and repeatability of egg weight and its components. *Poultry Science 32:504-510.*

Schwartz, Z. G and Allen, N.K. (1981) Effects of aging on the protein requirements of matured female Japanese quail for egg production *Poultry Science 60:3-348.*

Sekoni, A.A. (1994). A review on poultry research in National Animal Production Research Institute, Zaria. 2pp.

Shim, K.F and Vohra, P. (1984). A review of nutrition of Japanese quail. World Poultry Science Journal, 40: 261-275.

Siddique, K.D. (1996). Management and Production of Japanese quail. Iowa State Univesity Press, Ames, Iowa 24:209-323.

Snedecor, G.W and Cochran, W.G. (1973). Statistical Methods. The Iowa University Press Ames, Lowa, U.S.A.

Soller, M., T. Brody, Y Eitan, T. Agusky, and C. Wexler (1984). Minimum weight for onset of sexual maturity in female chickens. Heritability and phenotypic and genetic. Correlations with early growth rate. Poultry Science. 63: 103-2113.

Sooncharenying S; Edwards, H.M.(1986). Modelling the relationship of egg weight, specific gravity, shell ca and shell thickness Br. Poultry Science. 30 (3): 623-613.

Steel, R.G.D. and Torrie, J.H. (1980) Principles and procedures of statistical. A Biometrical Approach, 2nd Edn (New York, McGraw Hill).

Steigner, J.W; K.E Nestor, and M.S. Lilburn. (1992). Growth and development of lines of Japanese quail *(Coturnix coturnix japonica)* divergently selected for body weight at 4 weeks of age. Biochemistry Physiology. 102: 389-393.

Stino, F.K.R., Kicka M.A; Kamar G.A. and Alkakreti B.T.O. (1982). Egg quality traits of the Japanese quail and their heritability in subtropics British Poultry Journal 3: 104-108.

Sugiyama, M. (1991). Economic study of Japanese quail industry. World quail conference, Tartu-Tallin, Solvakia Republic. Pp. 9-18.

Taylor, T.G. (1970[a]). How an egg shell is made. Scientific American 222:89-95.

Taylor, J.W. (1970[b]). Mongraph of the land and fresh water Mollusca of the British Isles. 1 structural and general pp 454. Taylor Brothers, Leeds.

Thompson, M. (2001) Gamsel's, Quail "(Callipepla gambelii) "Animal Deversity. The " Canku Ota". A News better magazine: Celebrating. Native. America. http:// animal diversity. Ummz. Umich. Edu/site/accounts/information/callipepla gambelii.html.

Thaxton, G. (1978). Influence of temperature on the Immune response of birds: A review Poultry Science 57:1440.

Universities Federation for Animal Welfare (1967). Management and production of quails. Pub. E and D Livingstone Limited. U.K. London. 14: 821-829.

University of Florida / Institute of Food and Agricultural Science (1993). Factors that influence egg production. Animal science Department, Inst. of food and Agricultural Science, University Florida. EDIS Web site at http: // edis. Ifas. Uf /edu.

Varyhense, K.S. (2002) The Japanese quail. Mich. State University Department A.B., 4094. Ross St. R.R. n5, Forest, Out. Non. I. Jo.

Weibel, P.E and Devegowda (1982). Formulating diets to nutrients energy balance without setting an energy level Poultry. Science. 61:331.

Wethli, E; Morris T.R and Shresta T.P. (1975). British Journal of Nutrition 34:363-373.

Wilhelmson, M. (1975). Breeding experiments with Japanese quail (*Coturnix cotunix janoinca*). I. The synter of a random mated population. *Acta Agriculture Scandinav. Ca 25:177-200.*

Willis, M.B. (1991). Dalton's Introduction to practical animal breeding 3rd Blackwell Science. Publisher. London Edinbursh Boston 3rd Edition. Pp. 57.

Wilson, H.R; Nesbeth, W.G., Douglas, C.R and Miller, E.R. (1979). Forced resting bobwhite quail breeders and their subsequent reproductive performance, poultry Science, 58: 731-737.

Wilson, W.O., Abbot, U.K and Aplanalp H. (1961). Evaluation of *coturnix* (Japanese Quail) as a pilot Animal for Poultry. Poultry Science. 40: 697.

Wilson,W.O., Abbot, U.K and Abplanalp H. (1959). Development and physiological studies with a New York Pilot Animal for poultry *cuturnix.* Quail Journal Poultry Science. 38:1200.

Wolfrod, J.H. and Tanaka, K (1970) factors influencing egg shell quality – a review. World Poultry Science Journals, 26:763-780.

Yacowitz, H.R.F. Miller, L.C., Norris, and G.F Hevser (1952). Vitamin B_{12} studies with the hen. Poultry Science. 31: 89-94.

Yannakopoulos A.L and Tserveni – Gousi, S.A. (1986) Quality characteristics of quail eggs. British *Poultry Science 27: 171-176.*

Younger, M.S. (1985): A first course in linear regression second Edition. The University of Tennessee, Prindle, Weber and Schmidt, Duxbury Press. Boston.

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