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Research paper

Heritability estimates of egg weight and egg shell weight in Ikenne, Nigeria

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Abstract

This study is designed to determine the inheritance pattern of egg weight and egg shell weight of exotic laying chickens at 25, 51, 72 weeks and overall mean ages of the birds. For this purpose, thirty eggs were collected daily from the birds continuously for five days of egg production, at each ages 25, 51 and 72 weeks. The total number of eggs collected at each age was 150 and 450 for the total of three age periods. The mean values of egg weight and egg shell weight revealed an apparent increase from 25-72 weeks of age with their corresponding overall mean values. The least square means of egg shell weight at different age groups are significantly different at (P<0.01) while egg weight was significantly the same since egg shell weight depends on age variance for adequate performance. Statistical analytical system was used to obtain the variance components for the estimation of heritability. High and moderate heritability estimates were obtained when the age variance were included in the computation at different age groups for both traits while high, moderate and low estimates were obtained when the age variances were excluded. The heritability estimates from different egg quality traits were low to high. Since egg weight yielded high estimates at various age groups, the low and moderate heritability estimates recorded for egg shell weight imply that collection of additional records and improvement of non-genetic factors influencing the trait will improve the accuracy of characterizing the inherent ability of the birds.

Keywords: *Variance Components; Peak Egg Production; Age Variance; Egg Quality Traits; Genetic Potential; Heritability*.

1. Introduction

Poultry eggs provide means through which the animal protein requirements of the populace can be met. The Nigeria poultry population was put at 135 million comprising 82.4 million chickens (11% which was commercially raised) and 31.9 million other poultry which include pigeons, ducks, guinea fowls and turkeys [1]. Recently, chicken production is increasing due to increased product output per animal, high feed conversion efficiency, improved fertility, hatchability, growth rate, egg yield and meat quality. Poultry keeping requires less land, and most of the poultry species are more prolific than other species of livestock.

Poultry eggs has various uses and contains many essential nutrients; it supports life during embryonic growth and is one of the most nutritious and complete food known to man [2]. The hen's egg consists of the yolk (30-33%), albumen (approximately 60%), shell (9-12%), 4% cholesterol and its yolk has only 16-17% proteins [3].

Egg consumption has been accepted in Nigeria as a tool for meeting the animal protein intake and ingredient in a balance diet [4], [5]. The overall quality of egg has been considered as the most important trait by the producers and consumers as well for which continuous genetic evaluation of different egg quality traits has become essential in the Nigerian market scenario. Thus, to maintain the superiority in the total egg quality routine genetic and breeding experimentation must be carried out through genetic parameters such as heritability estimates for a number of chicken traits particularly the improved exotic breeds so as to select the best performers with respect to important economic traits through concentrating and enhancing the manifestation of the gene controlling these traits.

Heritability estimates are usually categorized into three classes viz: low (0 – 0.19), moderate (0.2 – 0.39) and high (0.4 and above) with its values in all classes ranging from 0 – 1 or 0 – 100%. Literature estimates cited in this paper are within the range of low to high [6-11].

Therefore, the aim of this research was to determine the heritability estimates in order to assess the inheritance pattern of various egg quality traits under the influence of age variance in Bovan Nera Black laying chickens.

2. Materials and method

2.1. Location of study

This research was carried out in the Teaching and Research Farm of Department of Animal Science, Babcock University in Ilare, Ikenne Local Government Area (LGA) of Ogun State, which has its Headquarter at Ikenne Remo. The Local Government Area is bounded 4km to the East by Odogbolu Local Government Area (LGA), 5km to the South by Ayepe, 10km to the North East by Irolu, 4km to the North by IIara, 2km to the East by IIishan, and 7km to the West by Sagamu. The Local Government is located along the transitional forest zone of Southern Nigeria and Guinea Savannah. Ilara is situated between Latitude 6.867 °N and Longitude 3.717 °E with an altitude of 235.2 meters above sea level in tropical rainforest belt of Nigeria. It has an annual rainfall of 1200mm, 65% mean relative humidity and 21.4ºC mean temperature.

2.2. Experimental birds and management

Thirty Bovan Nera Black laying birds from the flock of layers in the University Teaching and Research farm were randomly selected based on visual appraisal starting from 23 weeks of age. They were individually housed in labeled separated battery cage. The hen was caged individually in a 0.45 x 0.3.5m battery cage, and fed commercial diet formulated based on laying birds' requirements NRC [12]. Each bird was fed on average of 131g per head per day with water supplied and libitum for the period of 50 weeks of experimentation and data collection [13]. The detail of the experimental birds and management is found in John-Jaja et al. [13], [14].

2.3. Experimental design

Completely Randomized Design (CRD) was used at the first phase to select the healthy hen before laying commenced and visual appraisal at the second phase of design was used for selecting the layers that laid 5 – 6 eggs within a week from the flocks of Bovan Nera Black layers. Randomization was performed using a random number table, computer, program (i.e. number of treatments and replicates is only limited by the available number of experimental units) [13], [14].

2.4. Data collection

Thirty laying birds were randomly selected and housed in labeled separated battery cage. Each egg collected was identified and labeled by the appropriate identification numbers on the egg trays. A total of thirty (30) eggs were collected daily from the bird continuously for five (5) days of egg production, at each ages 25, 51 and 72 weeks. The total number of eggs collected at each age was 150 for three age periods (25, 51 and 72 weeks) [13], [14].

2.4. Measurement of egg quality traits

Each eggs collected was cleaned carefully with a soft damp cloth prior weighing to eliminate faecal and feed smeary which may reduce accuracy by elevating egg weight and consequently introducing bias. The egg weight was measured using a 0.09 sensitive digital scale. These were done by gently placing the egg on the flat surface of the scale ensuring that the scale was set to 0.0g before measurement. In order to determine the egg shell weight, the content of the eggs were emptied, the shell was thoroughly washed in running water, dried for two hours at 105ºC with the shell membrane intact, and weighed on an analytical scale to the nearest two decimal place (0.0g). Both petri dishes that was used in weighing the egg contents were initially weighed and the difference in the weights of the petri dish after and before the egg component were taken as the weight of the egg components. After each weighing the petri dishes were washed in clean water and wiped dry before next weighing [5].

2.5. Statistical metrics

The least squares means with the corresponding means at different age groups and overall mean and their respective standard error were estimated for egg weight and egg shell weight using Statistical Analytical System program [16]. Statistical analytical system was used to obtain the variance components for the estimation of heritability while the error in the estimation of heritability was calculated using Becker [14].

3. Results and discussions

3.1. Phenotypic least square means and standard error of egg quality traits

The investigated phenotypic least square means with standard errors of egg weight and egg shell weight are presented in Table 1. The least square means of egg shell weight at 25, 51 and 72 weeks of age are significantly different at ($P<0.05$) while egg weight are significantly the same with different magnitude. The least square means of egg shell weight at 72 weeks reported the highest value 7.81±0.07 which is significantly lower than 7.62±0.06 registered at 51 weeks and 6.36±0.04 recorded at 25 weeks of age; and the standard error for different age groups and overall mean age group indicates greater precision. This implies that the environmental effects were large and masked observable genetic variation on the egg shell weight except for egg weight. Similar reports were registered in literature. Paleja et al. [18] observed that egg weight at 32, 40 and 56 weeks of age were significantly the same with the different magnitude of 50.37, 51.65 and 52.43 respectively for white leghorn. Tadesse et al. [19] reported different magnitude of least square means of egg weight for intensive and village production systems for Isa Brown and Bovan Brown having the same significant attributes. However, Khali et al. [20] registered varying magnitude of both least square means of egg weight and egg shell weight with an observable significant difference at ($P<0.05$) for Golden Montazah and white leghorn breeds. These observable discrepancies could be attributed to the influence of environmental variance on the traits.

The mean egg weight and egg shell weight revealed an observable variation from one age group to another as presents in Table 1. This could be due to the genetic potential, and the prevailing environmental factor influencing each trait studied and the age of the layers as age is a major factor that influences to a great extent the growth and physiological development of the traits. The mean egg weight registered 55.02g at 25 weeks, 62.20g at 51 weeks and 63.29g at 72 weeks with a corresponding mean value of 60.17g for the overall ages of the hen depicting an increasing trend. These reports are similar to 57.78g registered by Rath et al. [7] for egg weight at 50 weeks employing white leghorns; 48.1-63.9g reported for single Comb and white leghorn at 25 – 65 weeks of age obtained by Chen et al. [18]. Sreenivas et al. [11] recorded 50.01 – 53.89g for three pure lines and one control lines of white leghorns at 40 weeks. Blanco et al. [6] obtained 60.3 – 62.4g for white egg lines of Lohmann Tierzucht Gambh at 67 – 70 weeks and Brown egg line of Lohmann Tierzucht Gambh at 32 – 36 weeks. Sabri et al. [8] registered 50.6 – 55.6g for white leghorn at 26 – 54 weeks of age. Paleja et al. [18] reported 45.67 – 51.33g for white leghorn (IWN line) at 32 – 56 weeks of age. Kamanli et al. [21] registered 60.3g and 61.1g for ATAK-S commercial layers hybrids at 52 weeks of age employing incandescent bulb, mini fluorescence and light emitting diodes. Ledur et al. [22] reported 58.0 – 62.1g for white leghorn at 35 – 65 weeks of age. Minelli et al. [23] observed 62.0 – 67.3g for commercial layers at 28 – 73 weeks of age. Tadesse et al. [24] obtained 58.75g, 60.27g and 48.8g for Iso Brown, Bovan Brown and Potchetstroom Koekoek breeds at 32 weeks of age. Molnar et al. [25] recorded 63.9g – 65.2g for commercial layers at 60 – 80 weeks of age. Tadesse et al. [19] reported 64.78g, 63.46g and 47.79 recorded for Isa Brown, Bovan Brown, Koekoek respectively under intensive production system and 58.92g, 59.32g and 47.53g reported for Isa Brown, Bovan Brown and Koekoek respectively under village production system. Akintola et al. [26] obtained 51.9 – 55.6g for Isa Brown under graded dosage levels of Ovabolin (0ug, 10ug, 20ug and 30ug) at 69 weeks of age. Tumova and Goust [27] reported 56.6g for young (22 – 29 weeks) and 68.6g for old (83.99 weeks) Lohmann Brown laying hens, 66.4g for young (36 – 73 weeks) and 7.1.6g for old (64 – 71 weeks) Cobb 500 broiler breeders. Ewa et al. [28] registered 53.30g and 56.72g for Block Olympia and H and N Brown Nick breeds respectively between 36 – 46 weeks of age.

However, lower value 42.87g was obtained for Iranian fowl at 30 weeks by Begli et al. [10]; Goto et al. [29] recorded 34.84g for Onagadori breed and 41.01g for white leghorn at 20 – 34 weeks of age for both breed. Islam and Dutta (30) reported 46.80g and 39.83g for Cobb 500 of broiler and Fayoumi breeds at 48 weeks of age. Khalil et al. [20] observed 44.0g and 45.7g for Golden Montazah and white leghorn respectively at 85 weeks. Whereas Petek et al. [31] reported higher values of 74.11g, 73.20g and 69.70g for commercial brown egg laying hens under effects of non-feed removal molting methods (non-molting control, Barley and Alfalfa respectively). The variation could be attributed to the breed differences, the age of the layers and environmental temperature as recommended by Kitalyi [32].

The bird egg shell weight exhibits a successive increase as the usage of the hen increases. At 25 weeks of age, egg shell weight recorded 6.39g, 7.62g and 8.81g at 25, 51 and 72 weeks of age with a corresponding value of 7.26g for the overall ages of the birds. These values agree favourably with the report in literature. Minelli et al. [23] reported 6.00g at 28 – 32 weeks, 6.16g at 47 – 50 weeks and 6.29g at 70 – 73 weeks of age. Rath et al. [7] 6.00g at 50 weeks recorded for white leghorns. Tumova et al. [33] obtained 6.91 – 7.81g at 28 – 60 weeks of age in New Black breed; and 6.50 – 6.91g for litter raised Hisex Brown at 60 weeks. However, Ewa et al. [28] registered lower values 5.05g for Black Olympia breed and 5.34g for H and N Brown Nick breed at 36 – 46 weeks of age. Begli et al. [10] observed 4.45g at 30 weeks of age for Iranian fowl. Goto et al. [29] recorded 4.75g for Onagadori breed and 5.60g for white leghorn at 20 – 34 weeks of age registered for both breeds. Sreenivas et al. [11] reported 4.32 – 5.12g for four genetic groups in white leghorn breed at 40 weeks. Khalil et al. [20] obtained 5.5g for both golden Montazali and white leghorn. These discrepancies could be attributed to the breed differences, the ages of the layers and environmental temperature as recommended by FAO [34].

Table 1: Least Square Means ± Standard Error of Egg Weight and Egg Shell Weight

Age	N	Egg Weight	Egg Shell Weight
Overall Mean	450	60.15±0.31	7.26±0.05
Age of Bird			
25	150	55.02±0.40^{b}	6.36±0.04^{a}
51	150	62.20±0.45^{b}	7.62±0.06^{b}
72	150	63.29±0.47^{b}	7.81±0.07^{c}

a, b, c: means in the same column with different superscript are significantly different P < 0.05 and N is the number of observation.

3.2. Heritability estimates

Statistical model 1 was employed to evaluate the heritability estimates of overall ages of egg weight and egg shell weight at 25, 51 and 72 weeks when the age of the bird was excluded from the computation and model 2 was used when the age of the bird was included as shown in Table 2.

High and moderate estimates of 0.6908±0.026 for egg weight and 0.3189±0.025 for egg shell weight using data from overall ages when the age of the bird were included suggesting higher role of additive genetic variance in phenotypic expression of these traits and the low standard error for different age groups and overall mean age group indicates greater precision. These estimates generally agreed with the report in literature. Rath et al. [7] obtained values of 0.443±0.160 and 0.223±0257 for heritability estimates of egg weight and egg shell weight respectively at 50 weeks of age for white leghorns using half-sib correlation analysis adopted to multifarious species and evaluated using PROC VARCOMP of restricted maximum likelihood (REML) method of statistical package for social science (SPSS). Begli et al. [10] registered 0.45±0.09 and 0.23±0.08 for heritability estimates of egg weight and egg shell weight respectively at 30 weeks using half-sib correlation analysis adopted to multifarious species and employed restricted maximum likelihood of ASREML software for the estimation of variance component. Sabri et al. [8] reported 0.490±0.071 and 0.343±0.070 for estimates of heritability of egg weight and shell weight respectively between 26 – 54 weeks of age using the method of ordinary least squares analysis of variance. Alpanah et al. [9] obtained 0.50 and 0.54 for heritability estimates of egg weight and egg shell weight respectively at 40 – 65 weeks of age using restricted maximum likelihood (REML). Blanco et al. [6] reported heritability estimates 0.49 for egg weight for male white egg lines of Lohmann selected leghorn and 0.65 for egg weight for male Brown egg lines of Lohmann Brown breed between 32 – 36 weeks using mixed procedure of statistical analytical system to a half-sib correlation analysis adopted to multifarious species.

However, low estimates of 0.1277±0.0091 and 0.0004 0.065 were registered for egg weight and egg shell weight respectively when the age variance was excluded from the computation. This variation could be attributed to the removal of age variance which determines its developmental processes and hence robust the non-additive gene actions thereby culminating into low, and more accurate estimates of heritability of the traits compared to the report of other genetic researchers [6-9]. Exception of the values of 0.180±0.122 and 0.161±0.079 obtained for egg weight and egg shell weight for IWI strain of white leghorns using full sib correlation method of mixed model least squares and maximum likelihood (LSMLML) computer software at 40 weeks by Sreenivas et al. [11].

At 25 weeks of age, high and moderate estimates of heritability of 0.7563±0.0275 and 0.3776±0.0453 were recorded for egg weight and egg shell weight. Theoretically, heritability estimates should decline in magnitude when the age variance was excluded from the computation resulting in decrease in the additive genetic variance. Practically, this trend was not observed in this research indicating minimal influence of non-genetic and permanent environment variance on heritability estimates of the traits of 25 weeks and hence higher to the estimates of egg weight reported by several genetic and breeding researchers [6-8] but lower to the estimates of egg shell weight obtained by Alipanah et al. [9].

However, there was a decline in the heritability estimates from moderate to low as registered for egg shell weight at 51 weeks. This indicates that excluding the age variance from the computation weakens the additive genetic variance as genetic potential reduces with advancing age and hence increasing the non-additive genetic and permanent environmental effects thereby reducing the estimates of the trait compared to the estimates in literature [7-9].

The heritability estimates enhanced from low to moderate as observed for egg shell weight 0.078±0.0388 to 0.225±0.050 while egg weight experienced a decline from 0.8519±0.0533 to 0.7681±0.0275 at 72 weeks. This indicates that the environmental effects were large and masked observable genetic variation on egg shell weight at 51 weeks while egg weight experienced same at 72 weeks of age.

Favourably, this trend was observed for shell weight in white leghorn [8], [35]. Grunder et al. [35] estimated heritability of several egg shell weight and economic traits at middle interval of egg production (42 – 45 weeks of age) and late (67 – 68 weeks of age) and observed that estimates were almost always higher when measured early compared with late in the laying year. Sabri et al. [8] observed that heritabilities for period 1 (26 – 30 weeks) were higher although not differing statistically than period 2 (50 – 54 weeks) for egg shell weight. This indicates that the genetic potential of egg shell weight was well expressed at peak egg production thereby minimizing the effects of environmental factors compared to later periods of the egg laying year in spite of excluding the age variance in the computation as observed in this study. Thus, the high heritabilities at early period of the laying year are advantageous because early selection decisions can be made. Consequently, the heritability estimates of egg shell weight enhanced from low to moderate (0.2251±0.0505) as observed at 72 weeks of age (see Table 2). The result obtained for the trait is not in agreement with the report of [6], [7] implying that the genetic potential of the trait was not well expressed at 72 weeks of egg production hence enhancing non-additive genetic and permanent environmental effects compared to egg shell weight in literature [7-8], [10], [35].

From the results, it could be observed that egg weight is more heritable compared to egg shell weight as the trait recorded high estimates at 25, 51 and 72 weeks of age whereas egg shell weight registered low and moderate estimates of heritability when the age variance were excluded from the computation in order to obtain a more realistic estimates hence identify traits that are more heritable under the influence of age variance.

Table 2: Age Variance, K-Value and Heritability Estimates± Standard Error for Egg Weight, Egg Shell Weight for Overall Ages of Birds, at 25, 51 and 72 Weeks of Age for Model 1 Analysis (age of bird excluded), Overall Ages of Bird for Model 2 Analysis (age of bird excluded)

Age Variance	K-value	Egg Weight [1]H±SE	Egg Shell Weight [1]H±SE
Age Included	15	0.6908±0.026	0.3189±0.025
Age Excluded	15	0.1277±0.0091	0.0004±0.0065
Age Excluded			
25	5	0.7563±0.0275	0.3776±0.0453
51	5	0.8519±0.0533	0.0780±0.0388
72	5	0.7681±0.0275	0.2251±0.0505

[1]H±SE represents heritability±standard error and K-value is the number of bird per record

4. Conclusion

From the findings, it was observed that as the age of the laying bird increases, the magnitude of the least squares means of egg weight and egg shell weight increases. The influence of age variance on heritability estimates of egg weight and shell weight were appreciable as considerable changes in heritability values recorded by excluding the effects of age variance thereby obtaining a more realistic estimates of heritability. However, since all the traits registered high and moderate heritability estimates at different weeks of age, these traits can be improve by mass selection. Improvement in the production environment and non-genetic factors influencing egg production will improve the accuracy of estimating the inherent transmitting ability of the layers in the moderately heritable trait observed for egg shell weight at 51 and 72 weeks and lowly heritable trait reported for same trait at 51 weeks under the influence of age variance.

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