Phenotypic and Genetic Parameter Estimates for Local Guinea Fowl Production and Some Other Traits

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AD, SYA, JKKA, GAZ and CGK designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors SYA, AD and CGK performed the statistical analysis and managed the analyses of the study. Authors AD and CGK managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

This study on indigenous Guinea fowls in Ghana was undertaken to estimate genetic variation and heritability of traits in these birds. The study was conducted at the Poultry Section of the Animal farm of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti campus, Ghana, from 2015 to 2018. The data used in the present experiment were collected from six hundred keets (300 males and 300 females) produced from randomly selecting and mating 110 dams and 22 sires and consisted of 780 records collected over a period of 3 years. The genetic parameters were estimated using sire-son, sire-daughter and dam-daughter regression analysis. Body weight and 8-month weight gain showed the greatest additive genetic variation, with survival, docility, dressing percentage, age at first egg, egg weight, egg number, fertility, hatchability traits, feed intake and FCR showing relatively low additive genetic variation. Moderate to high heritability estimates were obtained for body weight, weight gain at ages 1day to 2 months, 2-4

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months in females, 4-6 months in males, docility, feed intake in females and feed conversion ratio in both males and females. Similarly, moderate to high heritability estimates were also obtained for age at first egg, egg weight and egg numbers. However, all other parameters considered in this study had low heritability estimates. This study concludes that, the results could be used to initiate Guinea fowl selection breeding programmes.

1. INTRODUCTION

Guinea fowl production plays significant roles in uplifting rural economy in Ghana. Most of the people in Northern Ghana (Upper East, Upper West and Northern Region) depend on Guinea fowl rearing for their immediate cash needs. The ability of most of the traditional people to purchase farm inputs for crop production and food to sustain the family depends on this immediate cash need [1]. These abundant species of domestic animals, found in many traditional homes, do not only serve as source of income to the people but also provide meat and eggs [2].

The meat is a delicacy and a source of quality protein because it contains less cholesterol and fats [3]. In addition, the bird is used culturally for different purposes such as in funeral celebrations, sacrifices, courtship and as a token for settle disputes. Thus, Guinea fowl production is lucrative because there is high demand for both the meet and eggs. Because of its significant roles in the Ghanaian economy, Guinea fowl production in Ghana has gone through several developmental projects including Smallholder Agricultural Development Project (SADEP) between 1996-1999, Smallholder Rehabilitation and Development Programme Funded by the Government of Ghana and International Fund for Agricultural Development (SRDP/IFAD), Upper West Agricultural Development Project (UWADEP) and Market Oriented Agriculture Development Project (MOAP) since independence in 1957.

All these projects aimed to upgrade the productivity of the local Guinea fowl by increasing egg size and mature body weight through crossbreeding. Notwithstanding these developmental projects, there is still lack of improved breeds for farmers for extensive production and a call for breeders to embark on breeding programmes to genetically improve the local breeds of Guinea fowls [4,5]. In order to establish a breeding program, it is indispensable to estimate genetic parameters for improving the most important economic traits. The magnitude of the genetic parameter, for example heritability, could indicate the amount of improvement that can be achieved by selection. Genetic and phenotypic parameters such as mean, variance, heritability, genetic correlation and phenotypic correlations play a vital role to develop strains of animals [6]. Selection programme can utilize these values in order to bring about changes in genetic properties of a strain population [7].

Heritability estimates are indicators of additive genetic variances existing in a population. Production and reproduction traits are fundamental corner stone in enhancing the efficiency of the breeder birds. Body weight at different ages is important for the general health of birds which in turn influences the efficiency of egg production [8]. Similarly, age at sexual maturity, egg number, egg weight and egg shape indices are central towards selection of a breeder strain. Literature on heritability on production and other traits in local Guinea fowl is very rare. The present study was, therefore carried out to know the heritability estimates of these traits which can help improving the breeder strain in a continuous selection programme.

2. MATERIALS AND METHODS

2.1 Experimental Area

The study was conducted at the Poultry Section of the Animal farm of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti campus, Ghana, from 2015 to 2017. Mampong-Ashanti lies in the transitional zone between the Guinea savanna zone of the north and the tropical rain forest of the south of Ghana along the Kumasi-Ejura road. The average daily temperature is between 25°C and 30°C and the average relative humidity of the area is 70% [9].

2.2 Experimental Design and Treatments

The base population of the indigenous Guinea fowls used in this experiment was part of an original random bred population obtained from Animal farm of the Department of Animal Science Education, University of Education,

Winneba, Mampong-Ashanti campus, Ghana. The records used in the present experiment were collected from six hundred keets (300 males and 300 females) produced from randomly selecting and mating 110 dams and 22 sires of this base population, between May, 2015 to July, 2017. Seven hundred and eighty (780) records were collected from the keets during this period. The chicks were then taken to a brooding room immediately for brooding. The Guinea fowl keets were kept at a temperature of 35°C with adequate drinker and feeder spaces provided. Light was provided for 24 hours during brooding to avoid pilling and death. The temperature was reduced gradually at the rate of 3.50°C on weekly basis as brooding progressed [10]. The chick phase lasted for 4 weeks (28 days). At the end of the chick phase they were randomly distributed and raised on a slated wooden floor pen partitioned into 20 compartments with each compartment measuring 3 m x 4 m and housing 30 keets. Each sex was kept separately (Becker, 1984).

At day old keets were weighed and given individual dam and sire identities using permanent marker of various colours. Each keet was wing tagged and other records taken on it included, sex, hatch weight, 2-month weight, 4-month weight, 6-month 8-month weight, 2-month weight gain, 4-month weight gain, 6-monthweight gain, 8-month weight gain, response to sheep red blood cell (SRBC), docility, feed intake and FCR. Other records taken were dressing percentage, age at first egg, egg weight, hen-day egg production (egg numbers) fertility and hatchability. Similar records were also kept for the sires and dams of the keets for the purpose of parameters estimation. Feed intake was estimated from 250 keets (125 females and 125 males) aged 4-6 months that were randomly selected. At the end of 32 weeks (8 months), two males and two females from each of the pens were randomly selected for slaughter and their dressing percentage calculated

2.3 Management and Feeding of Experimental Birds

The birds were reared under similar managerial conditions. They were fed similar diet containing 22% protein and 2950 kcal/kg metabolizable energy for 1-8 week. Between 8-20 weeks the diet contained 20% protein and 2800 kcal/kg metabolizable energy (ME) and during laying 17.5% protein and 2780 kcal/kg. Feed and water were given *ad libitum*. The experimental birds were vaccinated against coccidiosis at 10, 23,

30, 44 and 60 days, Newcastle at 16, 49 and 112 days and fowl pox at 84 days. Livesol was used to control worms at three months interval. Cleaning of cages and grasscutter house was carried out daily. Feed and water troughs were also cleaned daily. Tables 1 and 2 show characteristics of the traits measured.

2.4 Measured Traits

2.4.1 Growth traits

Body weight (g/bird) was taken at day-old and every two months with the use of electronic balance; body weight gain (g/bird) was calculated by subtracting the initial weight from the final weight; the age at which birds within each group laid first egg was considered the age at first lay; eggs were sampled and weighed. Hen-day egg production was calculated as the percentage of the number of eggs laid to the number of hen days (Number of laying days x Number of birds alive); feed intake was calculated as the difference between the initial feed offered to birds and the feed left over; feed conversion ratio (FCR) was computed as the feed intake divided by the total weight gain.

Arithmetically, $\text{FCR} = \frac{\text{Total feed intake (g)}}{\text{Total weight gain (g)}}$.

2.4.2 Reproductive traits

The percentage fertility was calculated by expressing the total number of fertile eggs as a percentage of the total number of eggs set. The percentage hatchability was also determined by expressing the total number of eggs hatched as a percentage of total number of fertile eggs.

2.4.3 Carcass traits

Carcass (dressing) percentage was calculated as the ratio of the carcass weight to the live weight.

2.4.4 Docility

Docility was measured with the use of cage score on a scale of 1 to 4 (Hoppe et al., 2010) which was measured as follows: 1. Non-aggressive or docile (walks slowly, can be approached closely by humans, not excited by human presence). 2. Slightly Aggressive (runs along boundaries, will stand in corner if humans stay away. 3. Moderately Aggressive - (runs along boundaries, look for exits and will run eagerly if humans move closer). 4. Very Aggressive (excited in human presence, runs into boundaries, hitting gates and walls of the cage, avoids humans etc).

Table 1. Distribution of data used for estimating parameters in local male guinea fowls

Parameter	Acronym	Number of records	Mean	Range	Standard deviation
Hatch weight, g	HWT	300	25.95	28.5-23.4	1.06
2- month weight, g	TMWTG	286	461.09	528-409.1	31.84
4- month weight, g	FMWT	286	815.59	1070.2-637.67	71.73
6-month weight, g	SMWT	286	1578.76	1773.3-1420.3	61.19
8- month weight, g	EMWT	286	1759.69	1955-1505	58.85
Daily gain from 1-2 months, g/day	TMWTG	286	7.35	9.94-3.9	0.95
Daily gain from 2-4 months, g/day	FMWTG	286	7.67	9.98-5.18	0.60
Daily gain from 4-6 months, g/day	SMWTG	286	19.42	21.86-16.21	0.72
Daily gain from 6-8 months, g/day	EMWTG	286	4.26	10.64-1.32	0.88
Antibody response to SRBC (c/mil)	SRBC	144	7.68	11.50-4.50	0.62
Docility	DOC	288	2.91	3.60-1.20	0.44
Dressing percentage, %	DRESSP	104	0.64	0.78-0.57	0.06
Feed intake, g/day	FI	124	56.73	69.25-46.72	2.24
Feed conversion ratio	FCR	124	4.03	5.49-2.38	0.41

Table 2. **Distribution of data used for estimating parameters of local female Guinea fowls**

Parameter	Acronym	Number of records	Mean	Range	Standard deviation
Hatch weight (g)	HWT	300	26.88	28.9-23.2	1.09
2-month weight (g)	TMWTG	292	456.77	573.5-408.75	34.28
4-month weight (g	FMWT	292	828.45	987-534	49.93
6- month weight, (g)	SMWT	292	1583.19	1699.5-1398.5	49.34
8- month weight, (g)	EMWT	292	1810.21	2132-1590	53.41
Daily gain from 1-2 months (g/day)	TMWTG	292	7.82	9.67-6-19	0.56
Daily gain from2 -4 months, (g/day)	FMWTG	292	7.03	9.91-4.98	0.68
Daily gain from 4-6 months, (g/day)	SMWTG	292	19.22	21.09-17.28	0.45
Daily gain from 1-2 months, (g/day)	EMWTG	292	4.18	11.37-1.73	0.78
Survival	SVV	144	7.48	10.40-4.00	0.61
Docility	DOC	288	3.07	3.90-1.20	0.44
Dressing percentage (%)	DRESSP	104	0.63	0.74-0.49	0.03
Feed intake (g/day)	FI	124	57.47	67.57-47.17	2.43
Feed conversion ratio	FCR	124	4.21	6.90-2.43	0.61
Age at first egg (days)	ATFE	292	210.22	235-185	5.41
Egg weight (g)	EGGWT	168	41.06	49.2-37.8	1.24
Hen-day egg production (%)	HDEP	168	71.06	79.8-55	5.57
Percentage fertility (%)	FERT	168	0.59	0.73-0.36	0.03
Percentage hatchability (%)	HATCH	168	0.48	0.71-0.10	0.03

Response to sheep red blood cell (SRBC) antigen which was considered as an indicator trait of disease resistance or survival of the birds [11] was estimated by measuring total antibodies produced. Total antibody titers were measured by agglutination assays [12]. The procedure followed was similar to that used by [13].

2.5 Statistical Analysis

Phenotypic and genetic parameters estimated were; phenotypic and genetic variances, genetic coefficient of variation and heritability using sire-son and sire-daughter regression for all the parameters except egg characteristics where dam-daughter regression was used.

Phenotypic ($\sigma^2 p$) and genotypic ($\sigma^2 g$) variances were obtained according to [14] as:

$$\sigma^2 g = MSp - MSe/r \text{ and } \sigma^2 p = MSg/r,$$

where *MSp and MSg,* are mean squares of phenotypes and of genotypes respectively; *r* was number of replication. The mean values were used for genetic analyses to determine genotypic coefficient of variation (GCV), according to [15] as:

$$GCV\ (\%) = \frac{\sqrt{\sigma^2 g}}{X} \times 100$$

where: $\sigma^2 g$ = genotypic variance and *x* = sample mean. The linear statistical model for estimation of heritability was:

$$Z_i = \beta X_i + e_i$$

where Z_i = the mean of the offspring of the ith sire,
X = the observation on the ith sire,
β = the regression of Z on X and
e_i = the error associated with the Z's.

Genetic coefficient of variation was used as measure for ability of a trait to respond to selection and to determine genetic diversity of a trait in relative terms [16] Coefficient of variation was classified as low (0-20%), medium (> 20-< 40%) and high ($\geq$ 40%).

Heritability:

$$h^2 = 2\ cov_{xz}/\sigma^2_x = 2b$$

Standard error (S.E) of the heritability was calculated according to [17] as:

$$S^2_b = \frac{\Sigma z^2 - \frac{(\Sigma xz)^2}{\Sigma x^2}}{N - 2}$$

$$S.E.\ (b) = \sqrt{\frac{S^2_b}{\Sigma x^2}}$$

where b = the regression of offspring on parent.

3. RESULTS AND DISCUSSION

3.1 Variance and Coefficient of Variation Components Estimates of Traits

Table 3 presents estimates of components for variance and coefficient of variation of traits in local Guinea fowls. The values of phenotypic and genetic variances of both males and females followed a similar trend and were generally high for TMWT, FMWT, SMWT and EMWT. Feed intake was next to these weight traits. Hatch weight, TMWTG, FMWTG, SMWTG, EMWTG, SVV, DOC, DRESSP and FCR had the lowest $\sigma^2 p$ and $\sigma^2 g$.

An interesting order was observed between the males and females in terms of genetic coefficient of variation. With the exception of CVg of EMWTG which was medium in the males, all the other traits had low genetic diversity (variability) in both sexes. Conversely, there were some specific differences with respect to the traits that had low CV. While the CV_g of HWT, FMWT, SMWT, EMWT, TMWTG, SMWTG, DOC and DRESSP were higher in the males relative to their corresponding CV_g in the females, TMWT, FMWTG, SRBC, FI and FCR were lower in the males than their corresponding CV_g in the females. The results of coefficient of variation indicated that the genetic variance of six to eight month weight gain was generally higher than those of all other traits in both the sire and dam. This was followed by docility and the feed conversion efficiency in males while in females eight month weight gain was followed by FCR before docility.

Estimates of components for variance and coefficient of variation of egg traits are presented in Table 4. The values of phenotypic and genetic variances were high for age at first egg and hen-day egg production and low for egg weight, fertility and hatchability. All of the egg characteristics had low CV_g.

The degree to which most traits are inherited depends on how much the trait is affected by

genetics and how much it is affected by environmental factors [18,19] However, the genetic variation of a trait also plays a role because, instinctively, low variation means that regardless of what parents and individual has it will likely not be much different than other animals in the same environment. Therefore, the degree to which an individual resembles its parents more than other individuals is to some degree affected by the genetic variation of a particular trait.

Both genetic variance and coefficient of variation are used as measures of diversity in domestic livestock [20]. To compare ability to respond to selection and to make inferences about the forces that maintain genetic variability (diversity) are the two distinct reasons for making comparisons of genetic variation for quantitative characters. The reason for using the coefficient of variation (CV) is so that values from different populations can be compared (regardless of environmental variance), based on the assumption that two variables, X and Y, are actually identical (be that a value or a distribution), except that Y is k times as large as X (i.e. Y=kX) [21]. It may for example be of interest to compare two populations for the same trait to see if one population is more or less variable than the other, or compare different traits within a population that are measured on different scales, which is where CV becomes convenient. The coefficient of variation is the standard deviation divided by the mean for that population (CV= $s/\bar{x}$) [22]. Thus, the CV eliminates the units for traits and can therefore be used to compare distributions based on different units of measurement [23]. Consequently, the coefficient of variation was used as the final indicator of genetic variability (diversity) within a trait in the present study.

Estimates of phenotypic and genetic variances of traits in the indigenous Guinea fowls are very little in the literature. Though, current results obtained in this work are comparable to what generally pertains to other livestock species. The highest degree of additive genetic variation shown by body weight followed by feed intake in the present study has been reported Reproduction and survival have low genetic variation whereas body weight and growth traits have medium to high genetic variation [24,25]. However, genetic variation in growth rate in this study is lower than reported by [24,25]. Significant genetic variation has been reported

for feed intake and feed efficiency for beef cattle [26].

Genetic variation in feed intake in this study is lower than reported in other species. The low additive genetic co-efficient of variation obtained for traits in this study is probably due to the low genetic standard deviation, relative to the mean values of the traits. Genetic diversity, that is, the heritable variation within populations is usually acted upon by selection, be natural or artificial. Differential survival of individuals in a particular population in each generation due to selection ultimately results in changes in gene frequencies, hence evolution of such populations. Genetic diversity therefore allows for evolution as well as artificial selective breeding to occur [27]. Additive genetic variance is variance of breeding values. Therefore, medium to high genetic diversity in body weight will contribute to high response to artificial selection in these traits [24,25,28]. Traits (except those associated with size) will be difficult to improve via artificial selection due to low genetic diversity [24,25,28]. Due to the dearth of information in literature on heritability estimates in indigenous Guinea fowls, it is not feasible to compare the estimates obtained here for these traits with other previous reports with the exception of [29,30].

3.3 Heritability Estimates of Traits of Indigenous Guinea Fowls

In Table 5 are heritability estimates of body weight and body weight gain at various ages, antibody response to SRBC (Survival), docility, dressing percentage, feed intake and FCR in local Guinea fowls in Ghana. Estimates of heritability of body weight were high at hatch, month 2 and month 4, moderate at 6 and 8 in males. These were not different in the females with the exception of month 4 weight which was medium. Heritability values for body weight decreased with the age of the birds. The heritability estimates of body weight gain on the other hand did not follow a particular trend with respect to age in both sexes. However, these were moderate at month 2 and 6 but low at month 4 and 8 in the males whereas in the female counterparts the estimates were moderate at month 2 and 4 and low at 6 and 8. Heritability estimates for survival, dressing percentage and feed intake were all low in the males and females apart from feed intake which was medium in the females. Though both docility and FCR heritability estimates were higher in females compared to males, they were all moderate and ranged between 0.32 and 0.48.

Table 3. Variance and coefficient of variation components estimates of traits of indigenous Guinea fowls

Parameter	Male			Female		
	σ^2p	σ^2g	CV_g (%)	σ^2p	σ^2g	CV_g (%)
HWT	1.57	1.129	4.09	1.458	1.196	4.07
TMWT	1536.45	1014.055	6.91	1678.94	1175.26	7.51
FMWT	9529.11	5145.721	8.80	5418.79	2492.64	6.03
SMWT	7800.48	3744.231	3.88	6406.27	2434.38	3.12
EMWT	10184.85	3462.85	3.34	8913.45	2852.30	2.29
TMWTG	2.046	0.90	12.91	0.823	0.313	7.15
FMWTG	1.374	0.357	7.79	1.524	0.457	9.62
SMWTG	1.608	0.515	3.70	0.861	0.207	2.37
EMWTG	3.242	0.778	20.71	3.422	0.616	18.78
SVV	2.153	0.387	8.10	1.719	0.378	8.22
DOC	0.527	0.19	14.98	0.397	0.19	14.2
DRESSP	0.002	0.004	9.88	0.003	0.001	5.02
FI	17.96	5.028	3.95	16.46	5.927	4.24
FCR	0.422	0.169	10.2	0.844	0.371	14.47

σ2p = Phenotypic variance; σ2g = Additive genetic variance; CVg = Genetic coefficient of variation

Table 4. Heritability estimates of egg characteristics of local Guinea fowls

Trait	σ^2p	σ^2g	CVg
Age at first egg	86.2	29.31	2.58
Egg weight	2.67	1.547	3.03
Hen-Day Egg Production	39.82	31.063	7.84
Fertility (%)	0.01	0.001	5.36
Hatchability (%)	0.01	0.001	6.59

σ^2p = Phenotypic variance; σ^2g = Additive genetic variance; CVg = Genetic coefficient of variation

Table 5. Heritability estimates of traits of indigenous Guinea fowls

Trait	No. of records	H_s^2 ± S.E	H_d^2 ± S.E
Hatch weight	600	0.72 ± 0.30	0.82 ± 0.35
2-month weight	592	0.66 ± 0.35	0.70 ± 0.38
4-month weight	589	0.54 ± 0.28	0.46 ± 0.27
6-month weight	589	0.48 ± 0.28	0.38 ± 0.29
8-month weight	589	0.34 ± 0.29	0.32 ± 0.3
Daily gain from 1-2 months	592	0.44 ± 0.40	0.38 ± 0.4
Daily gain from 2-4 months	589	0.26 ± 0.40	0.30 ± 0.4
Daily gain from 4-6 months	589	0.32 ± 0.30	0.24 ± 0.25
Daily gain from 6-8 months	589	0.24 ± 0.32	0.18 ± 0.32
Antibody response to SRBC	144	0.18 ± 0.26	0.22 ± 0.3
Docility	288	0.32 ± 0.25	0.48 ± 0.3
Dressing percentage	104	0.26 ± 0.30	0.28 ± 0.26
Feed intake	124	0.28 ± 0.29	0.36 ± 0.29
FCR	124	0.40 ± 0.30	0.44 ± 0.3

h_s^2 = Heritability from sire-son regression, h_d^2 = Heritability from sire-daughter regression, S.E = Standard error

The results of heritability obtained in this study for body weight showed a declining trend in both males and females as birds grew older. The decrease in heritability estimate with age as observed in this study had been reported earlier by [31,32] for Japanese quails and [33] who worked on broiler breeders and reported similar decreasing heritability values (0.21, 0.20, 0.13 and 0.07) with increasing age of birds (4, 8, 12 and 16 weeks). The results however, disagreed with the findings of [34] who reported that heritability for body weight of broilers tends to increase with age and the findings of [35] who also reported that heritability estimates increase with age in Japanese quail and broiler chicken. [36] reported increasing heritability estimate with

age in domestic pigeon. Oni et al. (1991) reported heritability estimates of 0.413 and 0.044, 0.387 and 0.279 for body weight at 16 and 20 weeks in two strains of Rhode Island chickens. [37] reported an average h^2 estimate of 0.54 for bodyweight of Ghanaian local chicken from 0 to 40 weeks which fall within the range reported in this study. The heritability of body weight at ages day 1 and 2, 4, 6, 8 months ranged between 0.32 and 0.72 in males and 0.32 and 0.82 in females (i.e. medium to high) confirm the finds that the heritability estimates for body weight of the indigenous guinea fowl ranges from 35% at day old to 40% at 16 weeks of age and heritability estimates of 49% for body weight at 16 weeks of age [29,30]. The following authors [38] and [39] who reported 0.80 and 0.87 respectively for body weight. Higher heritability estimates (0.72–0.82) of hatch weight observed in the present study could be due to the intensive selection the birds had undergone for growth traits [40].

The moderate to high h^2 estimates for body weight implies that additive genetic variance made a greater contribution to the total phenotypic variance compared to environmental and gene combination variance. This implies that mass selection for any of the aforementioned trait could result to rapid improvement. The moderate to high heritability estimates obtained for body weight at ages 1 day, 2, 4, 6 and 8 months indicates that response to selection for body weight at these ages could be rapid. It can be used as criterion of selection to improve growth performance of local Guinea fowls.

The heritability estimates of body weight gain on the other hand did not follow a particular trend with respect to age in males whereas in females weight gain declined with increased in age. Estimates generally ranged from low (0.24) to medium (0.42) for males and low (0.18) to medium (0.34) in females. Heritability values for body weight gain obtained in this study are similar to those reported by [10] who obtained low to medium (0.19-0.42) in the Japanese quails. The low heritability estimates of body weight gain at months 4 and 8 in males and 6 and 8 imply that response to selection for body weight at these months could be slow.

3.4 Heritability Estimates of Fertility and Hatchability

Table 6 shows heritability estimates of fertility and hatchability in local Guinea fowls in Ghana.

Estimates of heritability of fertility and hatchability were low. The low heritability estimates 0.08, 0.12 and 0.18 (males) and 0.22 (females) for fertility, hatchability and survival respectively is in line with the assertion that reproductive and survival traits in livestock tend to have low heritability [24,28,41]. Natural selection of fitness traits (reproduction and survival) leads to loss of genetic variation, which results in low heritability [24,25]. Low heritability also suggests that factors other than additive genetic effects, which may or may not be subject to control by producers, account for substantial variation in these traits.

The medium heritability values for docility in both males and females (0.32 and 0.48 respectively) in this study suggest that docility is affected by additive genetic effects. These heritability results confirm the results of [42] who investigated the genetic basis of social aggressiveness in birds and documented heritability estimates of 0.34 in leghorn birds and 0.39 in birds from other strains, while overall heritability was 0.30. These findings indicate that selection to change the aggressive-ness is effective in birds, both between and within strains. The low heritability estimates for dressing percentage in Egyptian local chicks [43] is in conformity with this finding of 0.26 and 0.28 for males and females respectively. Several studies have shown that the heritabilities for FCR and FI are moderate to high in chickens [40]. In arkansas broilers, [40] reported that the heritability estimates of FCR and FI were medium which are similar to 0.44 and 0.36, respectively obtained in the females in this study. The value of FCR (0.40) of the males of the present study also agrees with these findings but the FI value obtained for the males (0.28) is in close consonance with the findings of [44] who reported that the estimates of heritability for FCR and FI were 0.19 and 0.21 at 37 to 40 weeks of age, respectively, and 0.13 and 0.29 at 57 to 60 weeks of age, respectively. Both FCR and FI had moderate heritability in females and FCR in males; consequently, genetic selection for FCR and FI can improve feed efficiency in female local guinea fowls and FCR for the male counterpart.

3.5 Heritability Estimates of Egg Characteristics of Local Guinea Fowls

Table 6 shows heritability estimates of egg characteristics in local Guinea fowls in Ghana. Estimates of heritability of egg weight and hen-day egg production were high, moderate at age at first egg and low for fertility and hatchability.

The moderate heritability estimate obtained for age at first egg (0.34 ± 0.16) in this study is similar to 0.48 reported by [10] but higher than 0.18, 0.27 and 0.31±0.18 documented by [10,44] in Japanese quail. Heritability value obtained for egg weight (0.58) is higher than 0.37 recognized by [32]. The h^2 estimate obtained for egg number (hen-day egg production), 0.78, was above the range of 0.30- 0.41 reported by [42] during a 70 days egg production period in Japanese quails but falls within the heritability estimates of egg number that ranged from 0.40-0.88 for 12-15 weeks period of egg production in Quail [43].

High heritability estimates recorded for egg weight and number and moderate estimate for age at first egg in the current study indicate that improvement in these traits would be possible using individual selection method. Differences in heritability estimates for different populations can be expected since heritability is a property of the population and the size or magnitude of the estimate is highly affected by such factors as selection, environmental deviations, method of estimation and sampling error due to small data or sample size [44]. Environmental (high temperature and humidity) and poor management conditions are known to increase the residual variance and decrease the heritability estimate.

Table 6. Heritability estimates of egg characteristics of local Guinea fowls

Trait	No. of records	H_f^2 ± S.E
Age at first egg	589	0.34 ± 0.16
Egg weight	168	0.58 ± 0.21
Hen-Day Egg Production	168	0.78 ± 0.17
Fertility	168	0.08 ± 0.15
Hatchability	168	0.12 ± 0.17

h_f^2= Heritability from dam-daughter regression, S.E = Standard error

4. CONCLUSION

The moderate to high heritability estimates obtained for body weight, weight gain at ages 1day to 2 months, 2-4 months in females, 4-6 months in males, docility, feed intake in females, FCR in both sexes, age at first egg, egg weight and egg numbers indicate that these traits seemed to have additive effect of genes and utilizing them as selection traits would improve both egg production and growth performance of local Guinea fowls. However, the low heritability estimates of the rest of the traits considered in this study imply that response to selection for those traits could be slow. The results could therefore be used to initiate Guinea fowl selection breeding programmers.

ETHICAL APPROVAL

Experimental protocols used in this study strictly conformed with the internationally accepted standard ethical guidelines for laboratory animal use and care as described in the European Community guidelines; EEC Directive 86/609/EEC, of the 24th November 1986 (EEC,1986).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Annor SY, Apiiga SY, Ahiaba JA. handbook on guinea fowl production in Ghana, 1st Edition. Quality type Limited. Accra. 2012;16-19.
2. Smith AJ. Poultry the tropical agriculturalist (revised edition). MacMillan with CTA. London, U.K. 2001;242.
3. Feltwell R. Small-scale poultry keeping. A guide to free-range poultry production. Faber and Faber Ltd. 1992;142-143.
4. Maphosa T, Kusina JF, Sibanda NJ, Makuza SM, Sibanda S. Village chicken production in small farming areas in Zimbabwe. Poster Presentation. Poster (J-17), Copenhagen, Denmark; 2002.
5. Machedeyi FC, Sibanda S, Kusina J, Makuza S. The village chicken production system in Rushinga District of Zimbabwe. Livestock Research for Rural Development. 2004;16(6).
6. Panda B. Inaugural speech. In: proceedings of XXVI th IPSACON, held at Mumbai. 2009;22-24.
7. Falconer DS. Introduction to quantitative genetics. 2nd Edition. Longman, New York and London. 1981;viii:340.
8. Dana N, Vander-Waaij EH, Van-Arendonk JAM. Genetic and phenotypic parameter estimates for body weights and egg production in Horro chicken of Ethiopia. Trop. Anim. Health Prod. 2011;43:21–28.
9. Meteorological Services Department (MSD). Annual Reports Mampong Municipal Assembly, Mampong-Ashanti, Ashanti Region, Ghana. 2017;15:9-12.

10. Momoh MO, Gambo D, Dim IN. Genetic parameters of growth, body and egg traits in Japanese quails reared in southern guinea savannah, Nigeria. Journal of Applied Biosciences. 2014;79:6947– 6954.

11. Dunnington EA, Martin A, Briles RW, Briles WE, Gross WB, Siegel, PB. Antibody responses to sheep erythrocytes for White Leghorn chickens differing in haplotypes of the major histocompatibility complex (B). Animal Genetics. 1989;20:213-216.

12. Helal MA. The effect of crossing on the performance of japanese quail. M. Sc. Thesis, Vet. Med. College, Alexandria Univ., Egypt. 1995;81.

13. Boa-Amponsem K, Dunnington EA, Siegel PB. Genetic architecture of antibody responses of chickens to sheep red blood cells. J. Anim. Breed. Genet. 1997;114: 443–449.

14. Baye TJ. View record in Scopus. Agric. Sci. 2002;139:161-168.

15. Singh K, Chaudhary BD. Biometrical methods in quantitative analysis Kalayani Publishers, New Delhi; 1985.

16. McLennan N, Lewer R. Wool production: Coefficient of variation of fibre diameter (CVFD). Department of Employment, Economic Development and Innovation, The State of Queens land. 2005; 19952010.
[Retrieve November 17, 2010]
Available:http://www2.dpi.qld.gov.au/sheep/1000 3.html

17. Klein TW, Defries CJ, Finkbeiner TC. Heritability and genetic correlation: Standard errors of estimate and sample size. Behavior Genetics. 1973;3:355-364.

18. Hill WG, Mulder HA. Genetic analysis of environmental variation. Genetics Research. 2010;92:381-395.

19. Shen X, Pettersson M, Rönnegård L, Carlborg Ö. Inheritance beyond plain heritability: Variance-controlling genes in Arabidopsis thaliana. PLoS Genetics. 2012;8:e1002839.

20. Tawefeuk FA. Studies in quail breeding using selection index for the improvement of growth and egg production in Japanese Quail. Ph. D. Thesis, Fac. Agric. Tanta Univ. Egypt. 2001;118.

21. Lewontin RC. On the measurement of relative variability. Systematic Zoology. 1996;15:141-142.

22. Sokal RR, Rohl FF. Biometry (2nd edn). New York: WH Freeman and Company; 1981.

23. ABDI H. Coefficient of variation. In: SAKIND N. (ed.) Encyclopedia of Research Design. Thousand Oaks, CA: Sage; 2010.

24. Nicholas FW. Veterinary genetics. Clarendon Press, Oxford, 1987;580.

25. Van-Vleck LD, Pollak JE, Oltenacu EAB. Genetics for the animal sciences. W.H. Freeman & Co., 1987;391.

26. Archer JA, Reverter A, Johmston DJ, Arthur PF. Genetic variation in feed intake and efficiency of mature beef cows and relationships with post-weaning measure-ments. Proceedings of the 7th World Congress on Genetics Applied to livestock Production. Montpellier, France, August 19-23, 2002: Communication No. 10-07; 2002.

27. Mensah GA, Okeyo AM. Continued harvest of the diverse African animal genetic resources from the wild through domestication as a strategy for sustainable use: A case of the large grass cutter (*Thryonomys swinderianus*) In: Animal Genetics Training Resource, version 2, 2006. Ojango, J.M., Malmfors, B. and Okeyo, A.M. (Eds). International Livestock Institute, Nairobi, Kanya and Swedish University of Agricultural Sciences, Uppsala, Sweden; 2006.

28. Blair HT. Practical procedures for the genetic improvement of growth and carcass quality characteristics. N.Z. Soc. Anim. Prod. Occas. Publ. 1989;11:125-139.

29. Ayorinde KL, Toye AA, Aruleba OA. Association between body weight and some egg production traits in a strain of commercial layer. Nigeria Journal of Animal Production. 1988;15: 119-121.

30. Sanjeev KH, Sharma RD, Kumar S, Singh H. Prediction of annual egg production on the basis of part record egg production in guinea fowl. Indian Journal of Poultry Science. 1997;32(2):122-125.

31. Saatci M, Dewi I, Aksoy R, Kirmizibayrak T, Ulutas Z. Estimation of genetic parameters for weekly live weight in one to one sire and dam pedigree recorded Japanese quail. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Paris, France. 2002; 20.

32. Daikwo IS. Genetic studies on Japanese quail (*Coturnix coturnix japonica*) in a Tropical Environment. Ph.D. Thesis,

College of Animal Science, University of Agriculture Makurdi, Nigeria. 2011;167.

33. Prado-Gonzalez EA, Ramirez-Avila L, Segura-Correa JC. Genetic parameters for bodyweights of Creole chickens from Southeastern Mexico using an animal model. Livestock Research for Rural Development. 2003;15(1).
Available:www.lrrd.cipav.org.co/lrr15/1/pra d151.htm

34. Chambers JP. Genetics of growth and meat production in chickens. In: Poultry Breeding and Genetics, Crawford, R.D. (Ed.). Elsevier Scientific Publishers, New York, USA. 1990;1123.

35. Resende RO, Martins EN, George PC, Paiva E, Conti ACM, Santos AI, Sakaguti ES, Murakami AE. Variance components for body weight in Japanese quails. Brazil J. Poult. Sci. 2005;7(1):2325.

36. Momoh OM, Anebi PE, Carew SN. Heritability estimates and phenotypic correlations of body and egg traits of domestic pigeon (*Colomba livia domestica*) reared On-station in Benue State of Nigeria. Res. Opin. Anim. Vet. Sci. 2013; 3(10):370.

37. Osei-Amponsah R, Kayang BB, Naazie A. Phenotypic and genetic parameters for production traits of local chickens in Ghana; 2013.
Available:https://www.researchgate.net/pu blication/258432446

38. Udeh I. Genetic parameters for some growth traits of Nigerian local chickens. Institute for Animal Husbandry, Belgrade-Zemun, Biotechnology in Animal Husbandry. 2017;33(1):65-71.

39. Hernandez EY, Segura JC. Estimation del indice de herencia para peso al nacer en pollos cuello desnudo. Universidad Ciencia. 1994;11:121-124.

40. Aggrey S, Karnuah A, Sebastian B, Anthony N. Genetic properties of feed efficiency parameters in meat-type chickens. Genetics Selection Evolution. 2010;42(1):25.

41. Abdel-Mounsef NA. Non-genetic factors affecting some productive traits in Japanese quail. MSc. Thesis Fac. of Agric. Al-Azhar Univ. Cairo Egypt. 2005; 66.

42. Komai T, Craig JV, Wearden S. Heritability and repeatability of social aggressiveness in the domestic chicken. Poultry Science. 1959;38(2):356-359.

43. Abdellatif MA. Genetic study on Dandarawy chickens. II. Heritability of live and carcass measurements. Genetics Selection Evolution, BioMed Central. 1989; 21(2):199-203.

44. Yuan J, Dou T, Ma M, Yi G, Chen S, Qu L. Genetic parameters of feed efficiency traits in laying period of chickens. Poultry Science. 2015;94(7):1470–5. [PMID:26009751]

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