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GENETIC GAINS FROM WITHIN-BREED SELECTION FOR EGG PRODUCTION TRAITS IN A NIGERIAN LOCAL CHICKEN

Vivian. U. Oleforuh-Okoleh
Department of Animal Science, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria
E-Mail: vivewa@yahoo.co.uk

ABSTRACT

This study aimed at estimating the genetic gain in egg production traits in a Nigerian local chicken ecotype (LE) population subjected to short-term (first ninety days of lay) selection over three generations. A selected and control line were established and monitored for the following egg production traits - Body Weight at First Egg (BWFE), Egg Weight (EW) and Egg Number (EN). Hens were selected based on a selection index constructed in each generation using the three traits as the selection criteria traits. A total number of 360, 769 and 1033 records were used in generations zero, one and two respectively. Selection differential and genetic response due to selection were estimated. A cumulative selection differential of 269.38g, 1.58g and 3.88 eggs were obtained for BWFE, EW and EN, respectively. Selection response for each trait increased over the generations. Realized response per generation was estimated to be 94.22g, 0.84g and 4.85eggs for BWFE, EW and EN, respectively. The simultaneous inclusion of BWFE, EW, and EN in a selection index generally improved the performance of selected birds over the generations in the LE.

Keyword: local chicken, genetic response, egg production traits, selection index, generations.

INTRODUCTION

Poultry management in Nigeria has been improving significantly with rapidly increasing production. However, one of the major constraints facing the Nigerian poultry industry today is lack of indigenous parent breeding stock. Importation of animals from one climatic zone to the other usually arises in a genotype x environment interaction, and subsequently a reduction in fitness (Ndofor-Foleng *et al*., 2006). A streamlined production of local chicken could be an option for alternative income generation and diversification of the agricultural production base of the nation. Local chickens may appear less productive when compared to specialized exotic breeds but they are highly productive in their use of local feed resources, adaptable to the harsh variable and extreme weather and climatic conditions making them more sustainable in the long term.

The Nigerian local chicken though often described as "a low producer" possess great potentials of a good layer (Nwosu and Omeje, 1985; Momoh *et al*., 2007). Incidentally, the rich genetic potentials of these chickens have not been harnessed and developed through a pure breeding strategy. Muchadeyi *et al.* (2007) and Halima *et al.* (2009) indicated that there are large phenotypic and possibly genetic variations existing within the indigenous breeds and varieties; and suggested the application of genetics and selective breeding towards improving the local breeds/ecotypes. For optimum production of the local chicken, therefore, there is need for genetic improvement. Strandberg and Malforms (2006) noted that selection within populations aims for genetic improvement which has continuous and long lasting effects. Improvement of quantitative traits by selection depends upon increasing the frequency of desirable genes. Thus, a breeding strategy which employs development of pure breeds and selection within local breeds is beneficial.

For rapid development and improvement of egg production in the local chicken, many traits that are economically important should be considered and genetically evaluated. A very excellent method of multi-trait selection is the use of a selection index. A selection index combines information from an individual's own and relatives' phenotypic performance for multiple traits into an overall score. It is an effective way of selecting breeding stock when several traits are being evaluated. An important genetic evaluation of improvement of traits is the genetic gain which arises due to existence of genetic variability. The genetic gain per unit time could be increased by reducing the age of the parents. In breeding of egg-birds, this is achieved by the use of early partial egg production records as selection criteria for improving annual egg production (John *et al*., 2000). Such breeding practice could be applied in the local chicken.

The purpose of the present study was to compare the genetic gains from within-breed selection by applying a selection index using body weight at first egg, egg weight and egg number (both from first egg to ninetieth-day of lay) as selection criteria traits in a Nigerian light ecotype chicken population.

MATERIALS AND METHODS

This study was carried out at the Teaching and Research Farm of the Department of Animal Science, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria using Nigerian light local chicken ecotype (LE). The experiment lasted for four years from 2003 to 2007 within which three generations of LE consisting of Selected and Control lines were produced. The selected line (S) and Control line (C) in the G_0 were hatched from a random-bred base population of Nigerian light local chicken ecotype (LE) maintained at the poultry farm of the Department of Animal Science, University of Nigeria, Nsukka, as a non-pedigreed, unselected and unimproved population, and were transferred to Abakaliki where the study was completed. Details of the light ecotype represents the chicken type obtained from the swamp, rainforest and derived savannah agro-ecological zones whose mature body weight ranges from 0.68 to 1.5 kg (Momoh and Nwosu, 2008). Feeding and management procedures observed can be found in Oleforuh-Okoleh *et al.* (2012)

Records obtained from 557 pullets belonging to 3 generations (2003-2007) of the LE under selection for short-term egg production (1st ninety days of lay) were used for this study. Data were collected and evaluated on the following selection criteria traits - Body weight at first egg (g) (BWFE) - this reflected the live weight of each pullet on the first day it laid egg; Egg weight (EW) - eggs laid by each hen was weighed on daily basis. The mean egg weight obtained from individual hen for each week of lay for each line over the short-term period was used in the data analysis. All weights were obtained using an electronic weighing balance (Mettler P1020N) having a sensitivity of 0.01g; and Egg number (EN) - this was taken as the total number of eggs laid by individual layer within the 1st ninety days of lay.

Selection procedure

Data collected on BWFE, EN and EW were used to construct an index in each generation of selection. The direction of selection was basically positive for all traits. To calculate the properties of the selection index, genetic and phenotypic parameter estimates (heritabilities and correlations) were estimated using paternal half-sib analysis method stipulated in Becker (1984). The total number of records used for each generation was 360, 769 and 1033 for G0, G1, and G2, respectively. Univariate heritability and means ± standard deviations, genetic and phenotypic correlations of the traits used in the index calculations for the 3 generations are shown in Tables 1 and 2, respectively.

Table-1. Heritability estimates (h^2) and Mean ± SD of traits used to construct the Index.

Traits[2]	G_0 h^2	G_0 Mean ± SD	G_1 h^2	G_1 Mean ± SD	G_2 h^2	G_2 Mean ± SD
BWFE	0.38	855.52±15.77	0.31	972±16.60	0.37	953 ±4.35
EW	0.34	36.81±0.29	0.21	37.69±0.31	0.27	37.13±0.27
EN	0.20	33.40±1.23	0.17	42.89±1.35	0.20	44.35±1.76

BWFE = Body Weight at First Egg; EW = Mean Egg Weight; EN = Total Egg Number

Table-2. Genetic (r_g) and Phenotypic (r_p) correlation by generation and population.

Gens.	Zero (G_0)		One (G_1)		Two (G_2)	
Traits[a]	r_g	r_p	r_g	r_p	r_g	r_p
BWFE-EN	-.61	-.29	-.74	-.18	-.47	-.70
BWFE-EW	.34	.24	.60	.25	.10	.24
EW-EN	.01	-.26	-.84	-.23	.05	-.11

BWFE = Body Weight at First Egg; EW = Mean Egg Weight; EN = Total Egg Number

All variance-covariance component analysis were performed using the mixed model least squares and maximum likelihood computer program PC-1 (Harvey, 1990). Economic values for each trait were derived used the prevailing market values of each traits such that the relative economic values changed with each generation. The selection index calculations were solved using Mathcad 7 professional (Mathsoft applications). The general solution to the index equation was $b = P^{-1}Ga$ according to Becker (1984), where P = phenotypic variance-covariance matrix; b = vector of partial regression coefficients (weights); G = genetic variance - covariance matrix; and a = vector of relative economic values. Only hens which ranked equal and above the index score were selected as parents of the next generation. Males were selected based on their mature body weight - average selection intensity of 7% was used for the cocks.

Estimation of selection differential and selection intensity

The within-generation changes induced by selection, that is, the selection differential (ΔS) for each trait was calculated, at each generation, by the difference between the mean values of selected birds and the mean value of the population from which they were selected. The value obtained was divided by the mean phenotypic standard deviation of the whole population to obtain the mean selection intensity - given in units of standard deviations - for the three generations of study (Ayyagari *et al.*, 1980). Cumulative selection differential associated with each individual was measured as the mean of selection differentials (ΔS) in the parental generation plus the mean cumulative selection differential from each previous generation (G) as follows:

$G_0 = C\Delta S_0 = \Delta S_0$, $G_1 = C\Delta S_1 = \Delta S_1 + \Delta S_0$ and $G_2 = C\Delta S_2 = \Delta S_2 + C\Delta S_1$ (Leymaster *et al.*, 1979).

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Estimation of genetic changes

The genetic changes (selection responses) were estimated as deviations of the means of the selected line from its unselected control line per generation. Regression of the cumulated responses on generation numbers was done in order to estimate the magnitude and direction of the average genetic change in the selection criteria per generation. Expected direct genetic change in one generation of selection for each trait in the selection criteria was estimated by: $\Delta G_i = h_i.\sigma_{gi}$, where, h is the square root of heritability of the i-th trait, σ_{gi} is the genetic standard deviation of the i-th trait (Yamada, 1958).

RESULTS AND DISCUSSIONS

Selection index coefficients in each generation are presented in Table-3. The index coefficients varied in the three generations of study since the economic values of the traits and the genetic parameters - hence, the aggregate genotype- varied from generation to generation.

Table-3. Selection index coefficients for the three generations of selection.

Generation	BWFE	EN	EW
G_0	0.341	- 0.496	3.006
G_1	0.265	- 0.668	1.866
G_2	0.353	- 0.600	0.848

BWFE = Body Weight at First Egg; EW = Mean Egg Weight; EN = Total Egg Number

The result reveals that of the three traits comprising the aggregate genotype, BWFE reflected the largest expected response in all three generations of study though it had the least economic weight associated with it and, therefore, should not have dominated the index. Hicks *et al.* (1998) reported that a trait that had the largest economic weight associated with it tended to dominate the index. However, the discrepancy between the report of Hicks *et al.* (1998) and the present study could perhaps be traced to the larger genetic and phenotypic variances of BWFE when compared to the other traits noting that the coefficient values of an index is more or less a function of both the phenotypic matrix and genotypic matrix (Lin, 1978). Of particular interest were the negative values associated with expected response for egg number in all the generations of study. This response could have as well resulted from the negative genetic and phenotypic correlation between egg number and the other traits.

Selection differential, selection pressure and selection intensity

Summary of the selection differentials, phenotypic standard deviations, genetic response from G_0 to G_2 for the selection criteria - BWFE, EW, and EN - are shown in Table-4.

Table-4. Selection differential, selection intensity, realized response, and estimated response per generation.

Traits[b]	Gen.	ΔS	σ_P	i	CΔS	ΔG_i	RR	CSR	ERR (b)
BWFE (g)	G_0	106.98	160.35		106.98	60.94	82.36	82.36	
	G_1	52.57	94.65		159.55	29.34	193.46	275.82	
	G_2	109.83	105.19		269.38	38.92	270.80	546.62	
	Mean	89.79	120.06	0.748					94.22
EW (g)	G_0	-0.30	3.3		-0.30	1.92	1.24	1.24	
	G_1	0.37	3.32		0.07	0.70	2.33	3.57	
	G_2	1.51	3.24		1.58	0.88	2.91	6.48	
	Mean	0.52	3.28	0.16					0.835
EN (Eggs)	G_0	0.74	11.6		0.74	2.32	0.10	0.10	
	G_1	0.31	12.93		1.05	2.06	6.14	6.24	
	G_3	2.83	12.35		3.88	2.47	9.80	16.04	
	Mean	1.29	12.29	0.105					4.85

Gen. = Generation; ΔS = Selection Differential; σ_P = Phenotypic Standard Deviation; i = Selection intensity; CΔS = Cumulative Selection Differential; ΔG_i = Expected Direct Genetic Gain; RR = Realized Response; CSR = Cumulative Selection Response; ERR (b) = Estimated Realized Response over three generations

Table-4 also shows the progress of selection during G_0-G_2 in the selected population. The mean response for each trait increased in the positive direction over the three generations of selection. Average response/generation was positive in all traits studied though this was not statistically significant (P>0.05). The estimated genetic response/total realized genetic progress from the three generations of study (obtained by regressing response on generation) was 94.22g, 0.834g and 4.85 eggs for BWFE, EW and EN.

Hill (1972) showed that genetic drift, individual measurement sampling, genotype - environment interactions and time trends in environment and natural selection are the possible causes of variable response in a selection experiment. However, the effects of selection on responses in the present study could not possibly have been affected by drift since selection was carried out only in three generations. Selection response tends to decrease and eventually disappear in long-term selection applied to a closed population as a result of increase in homozygosity or genetic drift due to inbreeding (Nwagu *et al*., 2007). The present study was a short-term selection, thus, the effects of inbreeding could not have been masked. Though negative response was expected from the index in egg number due to the negative genetic and phenotypic correlations estimated between EN and the other two traits (BWFE and EW) such was not observed in the phenotypic performance of the selected population - there were rather phenotypic increases over the generations of study.

Some authors have noted similar results. Sharma *et al.* (1983) showed that selections on the basis of an index (using data on body weight at 8 weeks, egg production to 300 days, and percent hatchability) was relatively more efficient than tandem selection or independent culling levels selection for all traits except hatchability. Comparisons between index selection and mass selection for various traits such as body weight at 8 and 20 weeks of age, 35-week egg weight, age at sexual maturity, and egg production to 260 days of age in white leghorn strains were made by Verma *et al.* (1984). For aggregate genetic response, index selection was found to be 2.76, 3.33, 13.66, 1.32 and 1.53 times more efficient than direct selection for egg production, egg weight at 35-week of age, initial egg weight, 20-week body weight and 8-week body weight respectively. Ayyagari *et al.* (1985) recorded similar observations in another white leghorn population and Makarechian *et al.* (1983) while working with indigenous chickens of southern Iran.

CONCLUSIONS

Generally, the simultaneous inclusion of the three traits (BWFE, EW, and EN) in the selection index, while selection was in a positive direction for the respective traits, improved the performance of the selected individuals in these traits. This virtually suggests that selection based on an index should be applied in breeding programmes for the development and/or improvement of egg production traits in the LE. Furthermore, the heritability estimates and genetic/phenotypic correlations of the selection criterion traits in this study were moderate to high; this is an encouraging factor for intense selection within the local chicken population before being crossbred with improved stocks in order to achieve new breed (s).

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