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Genetic Improvement of Egg Production Traits by Direct and Indirect Selection of Egg Traits in Nigerian Local Chickens

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Abstract

The study was carried out at Akpehe poultry farm, Makurdi.540 chicks produced from matings of 80 dams and 8 sires each of the Fulani and the Tiv local chickens ecotypes were used for the study. Sire, ecotype and dam had significant effect on age at first egg and body weight at first egg. Heritability estimates of age at first egg, body weight at first egg and egg weight due to sire variance component were high. There were significant positive genetic correlation between age at first egg, body weight at first egg and egg weight. Egg weight also had significant positive genetic correlation with egg length and egg diameter. Direct selection can be apply to age at first egg, body weight at first egg and egg weight in a multiple traits selection program to improve egg production traits. Indirect selection can also be apply to age at first egg and body weight at first egg in a multiple traits selection to exploit the correlated response to egg weight, egg diameter and egg length.

Keywords: Genetic-improvement; Genetic-correlation; Heritability, Local-chickens; Selection

Introduction

Indigenous chickens comprise about 80% of the national flocks in Africa and Asia. Despite their low growth rates and egg production, indigenous chickens are generally better in disease resistance and could maintain higher level of performance under poor nutrition and high environmental temperatures compared to commercial strains under village systems [1]. Studies on biodiversity of indigenous chickens in many parts of Africa revealed the presence of high genetic variability within ecotype populations [2-4] indicating the potential for genetic improvement of these chickens through selective breeding. Most breeding programmes aimed at improving the productivity of indigenous chickens has used cross-breeding. This approach has provided significantly higher productivity, but has resulted in a loss or dilution of the indigenous birds' morphological characters and instinct for broodiness [5]. Thus, a breeding programme involving local breeds should identify alternative breeding goals, and capitalize on the breeds' specific attributes. There are some estimates for growth [6,7] and egg production [8-11] traits in unselected indigenous chickens of Africa. However, genetic improvement of egg production traits by direct and indirect selection of egg traits in the local chickens using sire and dam, applying the population heritability estimates on egg traits had not being reported. The application of genetic correlation between these traits and egg weight, egg length and egg diameter to selection which may determine the direction of selection to improve egg production of the local chicken had also not been reported.

The aim of this study was to provide information on the effects of dam, ecotype, sire genetic additivity, heritability estimates and genetic correlation of these traits and their application to selection for genetic improvement of these traits. To identify the traits that should be included in breeding programs design for egg improvement and whether direct or indirect selection of these traits will be appropriate for the Nigerian local chickens.

Materials and method

The study was carried out at Akpehe poultry farm, Makurdi. Akpehe poultry farm is located on latitude 7041' N and longitude 80311E [12]. Makurdi is warm with temperature range of 17.3°C to 35.6°C. Rainfall is between 508 mm-1016 mm [13]. The relative humidity ranged from 47-85 percent [14]. The birds were housed in dwarf wall wire mesh screened pens roofed with corrugated roofing sheets. Each pen was partition by wire nettings into smaller units. The birds were reared singly in partitioned units on deep litter. The birds were given anti stress on arrival, vaccinated against Newcastle disease (Lasota), de-wormed and dusted for ecto-parasites and allowed to acclimatize for four weeks. They were fed a formulated diet containing 18 percent crude protein in the morning and evening, water was provided ad libitum. The hens were hand-mated. Eggs were collected from 160 hens produced from 80 dams by 8 sires in the ratio of 10 dams per sire for each ecotype. The eggs were marked according to ecotype, sire and dam and incubated. Five hundred and forty chicks were produced from the hatching.

The chicks were brooded on deep litter in separate units according to ecotypes, sires and dams. The chicks were fed formulated chick mash containing 20 percent crude protein. Routine vaccination and medication for prevention and control of prevalent diseases were carried out.

At grower phase, the pullets were moved to growing pens also partitioned into ten units for each ecotype, housing twenty five pullets per unit. Routine medication was carefully followed.

A 16 percent formulated grower mash was fed to the birds until age at first egg, when layer mash was introduced. Egg production was monitored for sixteen weeks.

Parameters that were measured

Data were collected on age at first egg, body weight at first egg, egg weight, egg diameter and egg length.

Data analysis

Data collected on ecotypes, sire and dam on age at first egg (AAFE) and body weight at first egg (WAFE) were used to assess their effect on age at first egg, body weight at first egg, Egg weight, egg length and egg diameter. The variance components for these traits were estimated by Restricted Maximum likelihood (REML), [15]. Heritability, Genetic and phenotypic correlations were estimated by the method of using the model below [16].

$Y_{ijkl} = \mu + S_i + D_j + Ek + e_{ijkl}$

Where

Y_{ijkl} = Single observation.

μ = population mean

S_j = Effect of sire (i = 1, 2 ....16)

D_j = Effect of dam (k = 1,2 ....160)

E_i = Effect of ecotype (I = 1,2)

e_{ijkl} = residual random error

SPSS was used to separate and rank the mean performance on age at first egg (AAFE) and body weight at first egg (WAFE) of the dams using DUNCAN multiple range test.

Results

Effect of ecotype on weight at first egg and age at first egg

There were significant (P<0.05) differences in the least square values due to ecotype on weight at first egg and age at first egg (Table 1). The Fulani ecotype were lighter (1.186 + 0.022kg) compared to the Tiv (1.486 + 0.104kg) and were earlier into production (19.530 + 0.104 weeks) than the Tiv ecotype (19.972 + 0.089 weeks) (Table 1).

Ecotype	WAFE ±	SE	AAFE±	SE
Fulani	1.186[a]	0.022	19.530[a]	0.104
Tiv	1.486[b]	0.104	19.972[b]	0.089
Total	1.359		19.785	

[a,b] Figures with different superscripts down the group are significantly different.
WAFE: Weight at first egg, AAFE: Age at first egg, SE: Standard error.

Table 1: Least mean squares values of weight at first egg and age at first egg due to ecotype.

Effect of sire and dam between ecotypes on weight at first egg and age at first egg

There were significant differences (P<0.05) due to effect of sire on weight at first egg and age at first egg (Table 2). The dam also had significant (P<0.05) effect on weight at first egg and age at first egg (Table 3).

Sire WAFE	WAFE ±	SE	AAFE ±	SE
1	1.096[a]	0.034	19.350[a] 0.162	0.162
2	1.199[a]	0.029	19.955[b]	0.139
4	1.343[a]	0.064	19.557[a]	0.309
5	1.181[a]	0.033	19.046[a]	0.161
6	1.421[a]	0.04	19.67[a]	0.191
7	1.315[a]	0.04	19.140[a]	0.191
8	1.489[a]	0.057	19.856[b]	0.273
9	1.250[a]	0.054	19.810[b]	0.273
10	1.592[b]	0.049	21.400[b]	0.259
11	1.487[a]	0.05	19.855[b]	0.236
12	1.686[b]	0.064	18.886[b]	0.309
13	1.673[b]	0.051	20.327[b]	0.247
15	1.600[b]	0.17	19.300[a]	0.818

[a,b,c] Figures with different down the group are significantly different, WAFE: Weight at first egg, AAFE: Age at first egg, SE: Standard error.

Table 2: Least means square values due to sire effect between ecotype on weight at first egg and age at first egg.

Dam	WAFE +	SE	AAFE+	SE
1	1.093[a]	0.044	19.500[a]	0.211
3	1.099[a]	0.051	19.200[a]	0.247
7	1.218[b]	0.051	20.264[b]	0.247
9	1.123	0.047	19.800[b]	0.227
10	1.255[b]	0.051	19.800[b]	0.247
23	1.221[b]	0.05	19.479	0.24
28	1.181[a]	0.033	19.046[a]	0.161
33	1.350[c]	0.07	19.350[a]	0.334
34	1.300[c]	0.076	18.900[d]	0.366
36	1.613[e]	0.06	20.788[c]	0.289
41	1.489[d]	0.057	19.856[b]	0.273
42	1.464[d]	0.051	19.300[a]	0.447
43	1.380[c]	0.076	18.720[d]	0.366
45	1.250[b]	0.054	19.810[b]	0.259
48	1.496[d]	0.089	20.300[c]	0.426
50	1.500[d]	0.076	19.860[b]	0.366
53	1.544[d]	0.057	19.600[b]	0.273
54	1.502[d]	0.039	20.763[d]	0.188

57	1.643^{e}	0.091	19.093^{b}	0.437
60	1.673^{e}	0.051	20.327^{c}	0.247
a,b,c,d,e Figures with different superscripts down the group are significantly (P<0.01) different. WAFE: weight at first egg, AAFE: Age at first egg				

Table 3: Least mean Square values of effect of Dam between ecotype on weight at first egg and age at first egg.

Analysis of variance result on effect of ecotype, sire and dam on weight at first egg and age at first egg

An analysis of variance indicated highly significant (P<0.01) effect of ecotype on weigh at first egg and age at first egg (Table 4). Sire on the other hand had no significant effect on weight at first egg and age at first egg (Table 4). The effect of dam highly significantly (P<0.01) affected weight at first egg and age at first egg (Table 4).

Sources of variation		Degree of freedom	Sum of squares	Means squares	Fcal
Ecotype	WAFE	1	0.327	0.327	11.899**
	AAFE	1	1.728	1.728	2.601*
Sire	WAFE	3	0.212	0.071	2.577ns
	AAFE	3	4.690	1.513	2.353ns
Dam	WAFE	9	0.594	0.066	2.405*
	AAFE	9	27.991	3.110	4.681**
Error	WAFE	194	5.329	0.027	
	AAFE	194	128.889	0.664	
Ns: Not significant. **Significant at P<0.01,*Significant at P<0.05), WAFE: Weight at first egg, AAFE: Age at first egg.					

Table 4: Analysis of variance result on effect of ecotypes, sire and dam on weight at first egg and age a first egg.

Dam ranking between ecotypes due to weight at first egg and age at first egg

Duncan's significant difference (P<0.01) in mean weight at first egg indicated superior Dams (Table 5). While the mean for superior dams between ecotype that came into production earlier are presented in (Table 6).

Dam	N	1	2	3	4	5	6	7	8
1		1.0927^{a}							
3		1.0991^{a}							
9		0.1231^{a}							
28		1.1808 ^{a}	1.1808^{a}						
7		1.2182 ^{a}	1.2182^{a}		1.2182^{a}				
23		1.2417^{a}	1.2417^{a}		1.2417^{a}				
45		1.2500^{a}	1.2500^{a}		1.2500^{a}				
10		1.2545^{a}	1.2545^{a}		1.2545^{a}				
34	5			1.3000^{b}		1.3000^{b}	1.3000^{b}		
33	6			1.3500^{b}		1.3500^{b}	1.3500^{b}	1.3500^{b}	
43	5			1.3800^{c}		1.3800^{c}	1.3800^{c}	1.3800^{c}	
42.00 11	1			1.4636^{d}		1.4636^{d}	1.4636^{d}		
41	9			1.4636^{d}		1.4889^{e}	1.4889^{e}		1.4889^{e}
50	5			1.5000^{e}		1.5000^{e}	1.5000^{e}		1.5000^{e}

54	19			1.5021^{e}		1.5021^{e}	1.5021^{e}		1.5021^{e}
53	9					1.5444^{f}	1.5444^{f}		1.5444^{c}
48	13						1.5769^{g}		1.5769^{g}
36	8						1.6125^{h}		1.6125^{h}
60	11								1.6727^{i}
57	8								1.6750^{j}

[a, b, c, d, e, f, g, h, i, j] Figures with different superscripts down the group are Significant at P < 0.05 N number of observation per dam. 1, 2, 3, 4, 5, 6, 7 and 8 are dam ranking due to body weight at first egg.

Table 5: Duncan's Dam ranking based on mean weight at first egg due to dam between ecotype.

Dam	1	2	3	4	5	6
43	18.7200^{a}					
43	18.9000^{a}	18.900^{a}				
57	18.9375^{a}	18.9375^{a}	18.935^{a}			
28	19.0462^{a}	19.0462^{a}	19.0462^{a}	19.0462^{a}		
3	19.2000^{a}	19.2000^{a}	19.2000^{a}	19.2000^{a}		
42	19.3000^{a}	19.3000^{a}	19.3000^{a}	19.3000^{a}		
33	19.3500^{a}	19.3500^{a}	19.3500^{a}	19.3500^{a}		
23	19.4917^{a}	19.4917^{a}	19.4917^{a}	19.4917^{a}	19.4917^{a}	
1	19.5000^{a}	19.5000^{a}	19.5000^{a}	19.5000^{a}	19.5000^{a}	
53	19.6000^{a}	19.6000^{a}	19.6000^{a}	19.6000^{a}	19.6000^{a}	
9		19.8000^{b}	19.8000^{b}	19.8000^{b}	19.8000^{b}	
10		19.8000^{b}	19.8100^{c}	19.8000^{b}	19.8000^{b}	
45				19.8100^{c}	19.8556^{d}	
41				19.8556^{d}	19.8600^{e}	
50				19.8600^{e}	20.2636^{f}	
7					20.3273^{g}	20.2636^{f}
60						20.3273^{g}
54						20.7632^{h}
						20.7632^{h}
36						20.7875^{i}
						20.7875^{i}
48						21.2308

[a,b,c,d,e,f,g,h,i,j] Figures with different superscripts down the group are Significant at P < 0.05). 1,2,3,4,5,6,7 and 8 are dam ranking due to age at first egg. N = number of observation.

Table 6: Duncan's Dam ranking based on mean age at first egg due to dam between ecotype.

Correlation between age at first egg and weight at first egg

There was a highly significant (P < 0.01) positive correlation (0.245**) between weight at first egg and age at first egg (Table 7).

Parameter	AAFE	WAFE	F
WAFE	0.245	-	0.000**
AAFE	-	0.245	0.000**

**Significant at P < 0.01, WAFE is Weight at first egg, AAFE: Age at first egg

Table 7: Correlation coefficient between weight at first egg and age at first egg between the ecotypes.

Heritability estimates from sire variance component of laying characteristic of the ecotypes

The heritability estimates of egg weight were high in both ecotypes (0.482 and 0.642) for the Fulani and Tiv ecotypes respectively (Table 8). These were followed by the heritability estimates of age at first egg for the Fulani (0.420) and body weight at first egg for the Tiv (0.438) ecotype. Egg length recorded the least heritability estimates (0.000) for the Tiv and (0.182) for the Fulani ecotype. The heritability estimates of egg diameter was low (0.051) in the Fulani and (0.0308) in the Tiv ecotype population (Table 8).

Parameters	Ecotype	
	Fulani (h2s)	Tiv (h2s)
Body weight at first egg	0.358	0.438

Age at first egg	0.420	0.398
Egg weight	0.482	0.642
Egg length	0.182	0.000
Egg diameter	0.051	0.309
(h2s) - Heritability estimate due to sire.		

Table 8: Heritability estimates from sire variance component of laying characteristics of the two ecotypes.

Genetic and phenotypic correlation of laying characteristics of the ecotypes

The genetic and phenotypic correlation estimates between egg laying characteristics of the ecotypes are presented in Table 9. In all, body weight at first egg had significant and positive genetic correlation (rG) with age at first egg and egg weight (Table 9). Egg weight also had a positive and significant (($P<0.01$) genetic correlation with egg length and egg diameter. The phenotypic correlations (rp) between body weight at first egg, age at first egg, and egg weight were positive, low and insignificant. The phenotypic correlation (rp) between egg weight, egg length and egg diameter were very low positive and also insignificant (Table 9).

Parameters	rG	rp
BOWE * AAFE	0.84	0.08
BOWE * EGW	0.78	0.06
EGW * EGL	0.88	0.01
EGW * EGD	0.79	0.10
BOWE: Body weight at first egg, AAFE: age at first egg, EGW: egg, weight, EGL: egg length, EGD: egg diameter, rG and rp genotypic and phenotypic correlations respectively.		

Table 9: Genetic and phenotypic correlations of laying characteristics of the two ecotypes.

Discussion

Effect of ecotype, sire and dam on weight at first egg and age at first egg

The significant differences in the least square mean on weight at first egg and age at first egg due to ecotype effect suggested that there was genetic dissimilarity between the ecotypes. The additive as well as the non-additive genetic effects controlling the potential of the birds in these traits varied. Pirany et al. [17] also observed genetic variability among strains of Indian local chicken in these traits. The Fulani ecotype was superior in this trait as it was lighter at first egg compared to the Tiv ecotype. This is an indication of the laying potentials of the Fulani ecotype as lighter breeds are good layers, as much of the feed consumed is directed towards egg production than to body building and maintenance as compared to heavy breeds.

The Fulani ecotype was also early into production compared to the Tiv ecotype. Age at first egg is a fitness trait which had shown the potentials of these ecotypes to be developed as terminal crosses to be crossed with other lines to develop a local layer breed. The non-significant difference due to effect of sire on weight at first egg and age at first egg indicated low additive influence on these traits. This may be due to low number of sires involved in these traits and also that, these are dam's traits. El-Labban et al. [18] also reported low additive genetic variance (6.8) and 35.5% for age at first egg and 3.0 and 30.9% for body weight at first egg in local chickens in Egypt. Emphasis must be on the dam in attempting to improve these traits. The significant ($P<0.05$) least square mean values and analysis of variance due to effect of dam on weight at first egg and age at first egg indicated that these traits are dam's traits, that are influenced by the additive and the non-additive genetic variation due to the dam. Other maternal effects like body condition, health status which is non-genetic but have great influence on these traits. Thus in attempting to improve these traits through selection and out-crossing superior dams, attention must be given to these non-genetic factors so that they will not limit the full expression of the genetic potential of the dam in these traits.

Dam ranking between ecotypes due to weight at first egg and age at first egg

The Duncan's significant difference in mean weight at first egg and age at first egg indicated that there were variations in these traits between dams. The mean difference also indicated superior dams in these traits that can be selected for genetic improvement.

The significant ($P<0.05$) positive correlation between weight at first egg and age at first egg indicated that selective breeding to improve weight at first egg will result in correlated improvement in age at first egg due to correlated response of selection for weight at first egg. El-Labban et al. also reported a positive correlation (0.84) of age at first egg and body weight at first egg [18,19].

Heritability estimates from sire variance component of laying characteristic of the ecotypes

The heritability estimates on laying characteristics of the two ecotypes observed in this study are higher than that reported by El-Labban [18]. This was because genetic estimates of egg production traits in different breeds exhibit a lot of variation in line with the differences in management practices adopted and the genetic make-up [20,21].

Genetic and phenotypic correlation of laying characteristics

Information on the magnitude and direction of genetic correlations among traits is very important in planning improvement program for the traits of interest. From the results of genetic and phenotypic correlations between egg laying characteristics in this study, it could be concluded that any improvement in age at first egg, egg weight; egg length and egg diameter will bring about good improvement because of the positive genetic correlation. Gwaza had reported positive genetic correlation between body weight and egg weight, egg weight and egg diameter [22]. The Phenotypic correlation among the traits followed the same pattern as genetic correlation except that they had lower values. Gwaza had also reported lower phenotypic correlations like the corresponding genetic correlations [22].

Application of heritability estimates and genetic correlation to selection for improvement of egg traits

Heritability estimates provide an insight on the additive genetic influence on a trait. High values indicate that such traits are highly heritable and can be transfer from parent to their offspring. It also guide on the appropriate selection method that can be apply to the population. Genetic correlation on the other hand, measures the degree of association between two traits. A highly positive genetic correlation as noted on egg laying traits would mean that selection for one trait will result in the improvement of the other. This is often advantageous if one of the correlated traits can be easily measure and when such traits are express at different times.

Direct and indirect selection for genetic improvement of egg production traits

The application of selection to a trait in order to exploit genetic improvement on the trait through selection response is often referred to as direct selection. This is often guided by the heritability of the trait. Indirect selection on the other hand is when selection is applied to another trait in order to improve the other.

Direct selection for genetic improvement of egg production traits

The high heritability estimates for body weight at first egg, age at first egg and egg weight imply that, these traits can be combines in a multiple traits selection with higher genetic gain.

This indicated that egg weight, age at first egg and body weight at first egg of the ecotypes could be improve by direct multiple traits selection simultaneously. Egg linear measurement however, cannot be improve by direct selection for the traits.

Indirect selection for genetic improvement of egg production traits

The significant(P<0.05) positive correlation between weight at first egg and age at first egg indicated that selective breeding to improve weight at first egg will result in correlated improvement in age at first egg due to correlated response of selection for weight at first egg. Atkare and El-Labban also reported a positive correlation (0.84) of age at first egg and body weight at first egg. Body weight at first egg was also highly correlated to egg weight [18,23]. Egg weight in turn was also highly correlated to egg length and egg diameter. Therefore, indirect mass selection for body weight at first egg will result to correlated response in age at first egg, egg weight, egg diameter and egg length.

Conclusion

Sire and dam had significant effect on body weight at first egg and age at first egg. The heritability estimates due to sire on body weight at first egg, age at first egg and egg weight were high. Direct selection of body weight at first egg, age at first egg and egg weight employing any of the multiple traits selection method may lead to genetic improvement of egg production traits.

There were significant positive genetic correlation between body weight at first egg, age at first egg and egg weight. Egg weight also had a significant positive genetic correlation with egg diameter and egg length. Indirect selection can be apply to body weight at first egg and age at first egg to enhance the correlated selection response to egg weight, egg diameter and egg length in local chicken populations.

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