Journal of Agricultural Science; Vol. 4, No. 6; 2012
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Egg Production Performance in a Nigerian Local Chicken Ecotype Subjected to Selection

Vivian Oleforuh-Okoleh (Corresponding author)
Department of Animal Science, Ebonyi State University, P.M.B. 53 Abakaliki, Ebonyi State, Nigeria
Tel: 234-803-607-2087 E-mail: vivewa@yahoo.co.uk

Christopher. C. Nwosu
Department of Animal Science, University of Nigeria Nsukka, Enugu State, Nigeria
Tel: 234-806-330-7657 E-mail: profnwosu@yahoo.co.uk

A. I. Adeolu
Department of Agricultural Education, Ebonyi State College of Education, P.M.B 02, Ikwo, Abakaliki, Nigeria
Tel: 234-803-632-8157 E-mail: sankarafarms@yahoo.com

I. Udeh
Department of Animal Science, Delta State University, Asaba Campus, Delta State, Nigeria
Tel: 234-806-386-7396

C. P. N. Uberu & H. M. Ndofor-Foleng
Department of Animal Science, University of Nigeria, Nsukka, Enugu State, Nigeria
Tel: 234-803-079-8330

Received: January 30, 2012 Accepted: February 20, 2012 Online Published: April 26, 2012
doi:10.5539/ jas.v4n6p180 URL: http://dx.doi.org/10.5539/ jas.v4n6p180

Abstract

This study aims to contribute towards the genetic improvement of Nigerian local chicken ecotype through selection. Genetic parameters for body weight at first egg (BWFE), egg number (EN) and egg weight (EW) till first 90 days of lay were estimated for both selected and control lines. Selection was based on an index using BWFE, EN and EW as the selection criterion traits. After three generations of index selection, BWFE, EN and EW all improved significantly (P<0.05) in the selected line. The heritability estimates for all traits in the three generations for both lines were moderate to high (BWFE, 0.33-0.56; EN, 0.19-0.28; EW, 0.25-0.44). Low to high positive genetic and phenotypic correlation was observed between BWFE and EW. The genetic and phenotypic correlation between BWFE and EN, and EW and EN were generally moderate to highly negative in both lines for all generations. However, in the second generation of the selected line a positive genetic correlation (0.33) was observed between EW and EN.

Keywords: Local chicken, Genetic parameter, Egg production, Traits, Selection, Generation

1. Introduction

Nigeria has rich chicken genetic resources. It has been reported by Resource Inventory management (RIM) (1992) that the local chicken contribute 80% of the 120 million poultry types raised in the rural areas of Nigeria. The local chicken, therefore, play a vital role in household food supply/income. It is known to be hardy and highly adapted to the harsh hot and humid environment, however, its productive potentials has not been fully harnessed - mainly because it has remained, to a large extent, unpedigreed, unselected and unimproved (Omeje, 1985). Studies relating to the development of the local chicken as a potential layer have shown appreciable improvement in egg production traits under improved management (Nwosu *et al.,* 1979; Adebambo *et al.,* 1999; Momoh *et al.,* 2007).

The egg production of the local chicken is a result of many genes acting on a large number of biochemical processes, which in turn control a range of anatomical and physiological traits. With appropriate environmental conditions (nutrition, light, ambient temperature, water, sound health, etc.), the many genes controlling all the processes associated with egg production can act to allow the chicken to express fully its genetic potentials (Fairfull and Gowe, 1990). Altering and improving the environment, physiological situation or manipulation of these birds though contribute immensely towards improvement of their production qualities, the possibility remains that variation in their productivity exists after optimum non-hereditary conditions have been established. A more permanent approach towards a sustainable productivity is genetic improvement, which can be achieved through selection and crossbreeding (Szwaczkowski, 2003).

The first strategy requires extensive sampling of local chickens throughout the country to select desirable genetic material that will constitute the base population, which will subsequently be crossed either with themselves or with other populations. Success of this strategy will largely depend on the initial response to selection. Though within-breed selection gives slowest genetic improvement especially if the generation interval is long, however, this improvement is permanent and cumulative, which is not the case for cross-breeding programs. Crossbreds from purebred parents show heterosis to the extent that their gene frequencies differ unlike hybrids from similar lines that manifest total heterosis. Several studies have been reported on crossbreeding of the local chicken with exotic breeds (Nwosu and Omeje, 1985; Adedeji *et al.,* 2008, Adebambo *et al.,* 2009). There has been no detailed information on selective breeding of the Nigerian local chicken. This paper reports results pertaining to the first three generations of selection based on selection index for increased body weight at first egg, and short-term egg production traits (egg weight and egg number) in a Nigerian light ecotype chicken population.

2. Research Method

2.1 Experimental Site

The study was carried out at the Teaching and Research Farm of the Department of Animal Science, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria. Abakaliki is located between Latitude 06^{o} 4'N and Longitude 08^{o} 65'E in the derived savanna ecological zone of Nigeria. Naturally, the day length of Abakaliki ranges between 12-14 hours all year round, it has an annual mean rainfall range of between 1500-2250mm with mean daily temperature ranges of 27^{o}C and relative humidity of 85% (Nwakpu, 2005). The experiment lasted for four years from 2003 to 2007 in which data on egg production traits were collected.

2.2 The Base Population and Management of Experimental Birds

The base population for the selection experiment was obtained from the 142 Light Ecotype chicken -LE- maintained at the poultry farm of the Department of Animal Science, University of Nigeria, Nsukka as non-pedigreed, unselected and unimproved random mating population. 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). Fifty-five LE (5 cocks and 50 hens) were randomly allotted to 5 breeding pens and allowed to mate naturally in a mating ratio of 1 cock to 10 hens. Eggs from the breeding population were collected over a period of 5-days and fumigated with 100ml of 20% formalin before they were set in the incubator. The eggs in each generation, prior to incubation, were identified according to pedigree (sire) using an indelible marker pen. A total number of 294 day-old chicks were hatched at Nsukka and transferred to Abakaliki for the study, this served as the foundation population (G_0). On arrival, all the chicks were weighed, wing-banded according to sire and brooded separately for eight weeks in deep litter pens. On the tenth week, sexing and separation of the males from the females were done using secondary sexual characteristics (comb size and shape of the tail feather). The pullets were reared in replicate pens until 18 weeks of age, when they were randomly assigned to individual battery cages measuring 17 x 32 x 32cm.

From 282 birds alive by the tenth week, 30 males and 30 females were randomly allotted into the control line from which the subsequent control generations (G_1 and G_2) were obtained. The control population spanned for three generations (each generation had its own control population of same age). These were used to monitor environmental changes and to estimate genetic change(s) due to selection. The remaining birds served as the whole population from which the selected line were obtained. The population size for the different generations of study is presented in Table 1.

In all generations and lines, feed and clean drinking water were given *ad libitum* throughout the experimental period. The birds were fed diets formulated by Bendel Feed and Flour Mill Ltd, Benin, Edo State Nigeria. The birds were fed chick ration during the first eight weeks (21%CP, 2750ME (kcal/kg); grower's diet (15%CP, 2300ME (kcal/kg) was fed between eight and eighteenth week of age and from the eighteenth week of age until after the breeding phase, layers' diet (17%CP, 2800ME (kcal/kg) was fed to the pullets (subsequently hens) whereas the males were maintained on the grower's diet until the breeding phase when they were fed similar diet as the females. The birds were vaccinated against the major poultry diseases prevalent in the study area, these included Newcastle disease (i/o, lasota, and komarov), infectious bursal disease, and fowl pox. Other medications such as antibiotics, coccidiostats, and vitamins were administered via drinking water as the need arose. Strict sanitary measures were adhered to.

2.3 Data collection and Statistical Analysis

2.3.1 Traits Measured

Data were collected and evaluated from the selected and control lines for three generations on the following egg production traits:

Age at first egg (days) (AFE) - this was taken as the number of days from hatch to the day the first egg was laid provided the second egg was laid in the next ten days;

Body weight at first egg (g) (BWFE) - this reflected the live weight of each pullet on the first day it laid egg;

Weight of first egg (g) (WFE) - the weight of the first egg laid by each hen as obtained soon after lay;

Egg weight (EW) – eggs laid by each hen was weighed on daily basis. The average egg weight obtained from individual hens for each week of lay for each line over the short-term period (90 days from first lay) was used in the data analysis. All weights were obtained using an electronic weighing balance (Mettler P1020N) having a sensitivity of 0.01g;

Egg number (EN) - this was taken as the total number of eggs laid by individual layer over the short-term egg production period.

2.3.2 Estimation of Variations in Egg Production Traits in Different Generations and Lines

The data on all traits in different generations and lines were subjected to a one-way analysis of variance using the General Linear Model of the SPSS (2001), significant means were separated using Duncan's test at 5% significant level. The statistical model was:

$$X_{ijk} = \mu + g_i + l_j + e_{ijk}$$

Where: X_{ijk} = the record of the k^{th} individual of the i^{th} generation in the j^{th} line; μ = the common mean for the trait being considered; g_i = the effect of the i^{th} generation ($i=G_0$–G_2); l_j = the effect of the j^{th} line (j= selected and control); and e_{ijk} = random error.

2.3.3 Estimation of Genetic Parameters

Variance and covariance components of genetic parameters (heritability, genetic and phenotypic correlations) for the selection criterion traits (BWFE, EW, and EN) were estimated using paternal half-sib model as stipulated by Becker (1984). The analysis done using the mixed model least squares and maximum likelihood computer program PC-1 (Harvey, 1990). The statistical model was as follows:

$$Y_{ij} = \mu + S_i + \epsilon_{ij}$$

Where: Y_{ij} = the record of the j^{th} progeny of the i^{th} sire; μ = the overall population mean for the trait being considered; S_i = random effect of the i^{th} sire; and ϵ_{ij} = uncontrolled environmental and genetic deviations attributable to the individuals within sire groups.

2.3.4 Selection Index

Selection was based on an index which combined data on individual BWFE, EN and EW. The direction of selection was basically positive for all traits. The selection index defined as: $I = b_1X_1 + b_2X_2 + b_3X_3$, was calculated for each generation of selection using the matrix notation $P\underline{b} = G\underline{a}$ according to Becker (1984).

Where: I = total index score; b_1, b_2 and b_3 = standard partial regression coefficients of the traits in the index; X_1, X_2, and X_3 = phenotypic values of the traits (BWFE, EN and EW respectively); P = phenotypic variance-covariance matrix; $\underline{b}$ = vector of partial regression coefficients (weights); G= genetic variance –covariance matrix; and $\underline{a}$ = vector of relative economic values.

3. Results and Discussion

3.1 Effect of Selection on the Various Egg Production Traits in Different Lines and Generations

The means of the egg production traits studied AFE, WFE, BWFE, EW, and EN for the selected and control lines in different generations of selection are presented in Table 2. There were significant differences (P<0.05) in AFE between the generations in the selected line. Such differences were not observed in the various generations of the control line (P>0.05). Birds in the selected line laid eggs later than the control line. Tule (2005) worked with a random-bred population of LE and reported an average AFE of 156.5 ± 0.70 days and 155.85 ± 0.62 days for LE hens raised in the deep litter and battery cage respectively. This is not so different from the result obtained in the control line. Invariably, the discrepancy between the AFE for birds in the selected line and those in the control line is most probably as a result of the application of selection in the former populations which affected their performance. Birds in the control line had the least WFE whereas the selected line had the highest (P<0.05). Omeje and Nwosu (1983) reported a mean WFE of 25.98g for the Nigerian local chicken. Tule (2005) worked with the grandparents of the foundation population of this study and reported a mean WFE of 25.70g. The findings of this study show that the mean WFE obtained was at least 15.53% greater than these reports. Presumably, this difference could be traced to effect of selection on this trait over the generations. BWFE differed significantly (P<0.05) between the two lines and between G_0 and the subsequent generations (G_1 and G_2) of the selected line. Such differences did not exist (P>0.05) in the control line. The mean BWFE of the LE over the three generations for the control line were generally within the range reported for unselected local chicken in southern Nigeria (Okpeku *et al.*, 2003; Ogbu and Omeje, 2011) and by Ndofor-Foleng *et al.* (2010) for the LE. The increase in the BWFE, AFE, WFE and EW in subsequent generations of selection confirms the report of Barbato (1999) that body weight has been shown to be highly responsive to selection such that genetic improvement for growth has resulted in increase in the egg weight and age at sexual maturity.

The average short-term egg weight for the two lines was 36.82g with a range of 35.50 – 37.74g. Least EW was observed in the control line while the highest was obtained from the selected line (P<0.05). The EW in the last generation of selection was quite close to that obtained by Momoh *et al.* (2010) for the Nigerian heavy ecotype. An average of 38.56 eggs was obtained as the short-term egg number for the LE in the present study. The total number of eggs laid by the selected line increased significantly (P<0.05) within three generations of selection. The results of the present study with regards to total egg number indicates that egg number of the local chicken after three generations of selection was an average of 47.13 eggs for the selected population for the short term (90 days from first lay) production period investigated. This is similar to the report of Abdou and Kolstad (1984) for Fayoumi (44 eggs) and white Baladi (41 eggs). Gowe (1970) in his work on long-term selection for high egg production in 2 strains of Leghorn reported that selection for part-period hen-housed egg production was effective in increasing the performance of the selected strains. Birds from the control line laid on average less number of eggs (35.61 eggs) than those from the selected line (41.51eggs). Furthermore,

3.2 Estimates of Genetic Parameters of the Selection Criterion Traits

The heritability estimates using paternal half-sib variance analysis for the selection criterion traits by line and generation are presented in Table 3. The estimates for BWFE in two lines and generations varied from moderate to high. The selected line had relatively higher heritability estimates (0.41 to 0.56) for all generations studied, though the estimate decreased with each generation of study. The h^2 for the control line ranged from 0.33 in G_1 to 0.44 in G_0. Heritability estimates for EW were moderate to high ranging from 0.26 in the G_1 of the control line to 0.44 in the G_0 of the selected population. The heritability estimates of EW in the selected line showed a similar trend as that of the BWFE (decreasing with subsequent generations). Conversely, the h^2 for the control line increased with subsequent generations ranging from 0.25 in the G_0 to 0.32 in G_2. As shown in Table 3, estimated heritability for EN was moderate for all generations of study irrespective of the line. Highest heritability estimates 0.28 and 0.26 were obtained in the selected line in G_0 and G_1 respectively. The estimate obtained in G_2 (0.20) of the selected line was the same with that of control line.

The heritability estimates especially those of the selected line are on average close to the findings of Lwelamira *et al*. (2009) who worked on two Tanzanian chicken ecotypes. They reported heritability estimate of 0.45±0.09 and 0.43±0.07 for body weight in Kuchi chicken and Medium ecotypes respectively. Momoh and Nwosu (2008) worked with the Nigerian heavy ecotype and reported that values of heritability estimates of body weight of the heavy ecotype increased from 0.18 at 4 weeks to 0.43 at 8 weeks and thereafter declined to 0.16 at the 16^{th} week to rise again to 0.30 at the 20^{th} week. EN showed a moderate heritability in both lines and generations of study. The estimates obtained affirms those of Dana *et al.* (2011), who reported heritabilities of monthly egg numbers ranging from 0.20 to 0.56 in Horro chicken of Ethiopia. Estimates of heritability for egg number for both lines and generations in this study falls within this range. The heritability estimates for egg weight obtained for the different lines and over three generations in the present study with LE using sire component ranged from 0.21 to 0.56 indicating a moderate to high additive genetic variance for egg weight in the LE.

Genetic and phenotypic correlation between the selection criterion traits are presented in Table 4. The pattern of variations in the genetic and phenotypic correlations between the various traits studied in the selected and control lines were not consistent as those observed in the case of the heritability estimates. This is in line with Fairfull and Gowe (1990) who attributed such variation partly due to the fact that genetic correlations are generally estimated with less precision than heritabilities. However, the correlation estimates appeared to be more with other reports in the control line. This was especially true for the genetic correlations involving BWFE and EW, BWFE and EN, and EW and EN in G_1 and G_2. The results of this study affirm those of several reports stating negative correlations (phenotypic and/or genetic) between BWFE and EN, and between EW and EN or egg production (Jeyarubau *et al.,* 1996; Francesch *et al.*, 1997). The genetic correlation between EW and EN in the present study, however, was positive in the G_2 of the selected population. This change in magnitude could be attributed to the selection method applied. Here, selection was based on an index score where, the selection criterion traits, BWFE, EW and EN were all selected for in a positive direction. In other words, only hens which ranked above or were equal to the index score were selected as parents of the next generation. Such selection tends to have increased the gene frequency of the favoured genes, which in the course of recombination were probably transmitted together as linked genes and translated to the maximum performance observed in the selected line. This should be of much interest to the breeder of LE, for perhaps with continuous selection and breeding, the LE could become the White Leghorn of Nigeria.

4. Conclusion

It is evident that the simultaneous inclusion of BWFE, EW, and EN in the selection index generally improved the performance of the selected line over the three generations of selection in the LE. 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).

Acknowledgements

The authors are grateful to the Department of Animal Science, University of Nigeria, Nsukka for providing the foundation population used for this study, and the Department of Animal Science, Ebonyi State University, Abakaliki for the kind permission to use the facilities at the Department for this study.

References

Abdou, F. H., & Kolstad, N. (1984). *A study on the performance of Norwegian and Egyptian breeds of laying hens and their crosses XVII Worlds Poultry Congress*, Helsinki, Finland.

Adebambo, O. A., Ikeobi, C. O. N., Ozoje, M. O., & Adenowo, J. A. (1999). Colour variation and performance characteristics of the indigenous chickens of south-west Nigeria. *Nig. Journal of Animal Production, 26*, 15-22.

Adebambo, A. O., Ikeobi, C. O. N., Ozoje, M. O., & Adebambo, O. A. (2009). Variation in growth performance of pure and crossbred meat type chickens. *Nig. Journal of Animal Production, 36*(2), 211-227.

Adedeji, T. A., Ojedapo, A. O., Ige, S. A., Akinwumi, A. O., & Amao, S. R. (2008). Genetic evaluation of growth performance of pure and crossbred chicken progenies in a derived savannah environment. *Proc. of the 13th Annual Conference of the Animal Science Association of Nigeria, (ASAN),* Sept. 15-19. ABU Zaria: 8-12.

Barbato, G. F. (1999). Genetic relationships between selection for growth and reproductive effectiveness. *Poultry Science, 78*, 444-452.

Becker, W. A. (1992). *Manual of Quantitative Genetics*. (5th Ed). Academic Enterprises, Pullman, Washington.

Dana, N., vander Waaij, E. H., & van Arendonk, J. A. M. (2011). Genetic and phenotypic parameter estimates for body weights and egg production in Horro chicken of Ethiopia. *Tropical Animal Health and Production, 43*, 21-28. http://dx.doi.org/10.1007/311250-010-9649-4

Fairfull, R. W., & Gowe, R. S. (1990). Genetics of egg production in chickens. In R.D. Crawford, (Ed), *Poultry Breeding and Genetics.* (705-760) Elsevier Science, Amsterdam.

Francesch, A., Estany, J., Alfonso, L., & Iglesias, M. (1997). Genetic parameters for egg number, egg weight, egg shell colour in three Catalan poultry breeds. *Poultry Science*, *76*, 1627-1631.

Gowe, R. S. (1970). *Long-term selection for egg production in two strains of chicken*. http://www.poultryscience.org/pba/1952-2003/1970%20Gowe.pdf

Harvey, W. R. (1990). *Mixed model least square and maximum likelihood programme.* Ohio State University, Ohio, USA.

Jeyarubau, M. G., & Gibon, J. P. (1996). Estimation of additive genetic variance in commercial layer poultry and simulated populations under under selection. *Theor. Appl. Genet., 92*, 483-491.

Lwelamira, J., Kifaro, G. C., & Gwakisa, P. S. (2009). Genetic parameters for body weight, egg traits and antibody response against Newcastle disease virus (NDC) vaccine among two Tanzania chicken ecotypes. *Tropical Animal Health and Production, 41*, 51-59.

Momoh, O. M.., Ehiobu, N. O., & Nwosu, C. C. (2007). Egg production of two Nigerian local chicken ecotype under improved management. *Proc. of the 32nd Annual Conference of Nigerian Society for Animal Production,* 18th-21st March University of Calabar: 278-281.

Momoh, O. M., & Nwosu, C. C. (2008). Genetic evaluation of growth traits in crosses between two ecotypes of Nigerian local chicken. *Livestock Research for Rural Development, 20*(10). http://www.Irrd.org/Irrd20/10/momo20158.htm

Momoh, O. M., Ani, A. O., & Ugwuowo, L. C. (2010). Part-period egg production and egg quality characteristics of two ecotypes of Nigerian local chickens and their F_1crosses. *International Journal of Poultry Science, 9*(8), 744-748.

Ndofor-Foleng, H. M., Ngongeh, L. A., Iberu, C. P. N., & Nwosu, C. C. (2010). Evaluation of the performance of two local chicken and the main cross ecotypes reared in Nsukka, Enugu State, Nigeria. *International Journal of science and Nature, 1*(2), 179-182.

Nwakpu, C. (2005). *Practical guide to lowland rice production in Nigeria.* (1st ed). SNAAP Press Ltd. Enugu.

Nwosu, C. C., & Omeje, S. I. (1985). Short-term egg production parameters of the local chicken and its F1 crosses with gold-link under different housing types. *East African Agric. and Forestry Journal, 51*(1), 49-53.

Nwosu, C. C., Obioha, F. C., Onuora, G. I., Gaven, F., & Igiran, G. D. (1979). An annual egg production performance including feed and housing consumption of deep litter raised local and exotic chickens. *Local chicken resource project report: 000118/76,* University of Nigeria, Nsukka.

Ogbu, C. C., & Omeje, S. S. I. (2011). Within population variation in performance traits in the Nigerian indigenous chicken (NIC). *International Journal of Science and Nature, 2*(2), 192-197.

Okpeku, M., Orheruata, M., & Imunorin, I. G. (2003). Phenotype, genetic variation among local chickens in Edo State of Nigeria. *Journal Society of Animal Production*, *28*, 119.

Omeje, S. I., & Nwosu, C. C. (1983). Egg production patterns in local chickens and their crosses in short term. *Nig. Journal of Animal Production, 10*, 91-96.

Omeje, S. S. I. (1985). Genetics of body weight heterosis in local and Gold-link crosses. *Ph.D thesis.* Dept. of Animal Science, University of Nigeria, Nsukka.

Resources Inventory Management Ltd – RIM. (1992). *Nigerian livestock resources survey.* (Vol. II). Federal Department of Livestock and Pest Control Services, Abuja, Nigeria. 287.

SPSS. (2001). Statistical package for social sciences version 13.0. SPSS Inc, Chicago, U.S.A

Szwaczkowski, T., Cywa-Benko, K., & Wezyk, S. (2003). A note on inbreeding effect on productive and reproductive traits in laying hens. *Anim. Sci. Papers and Reports, 21*(2), 121-129. Institute of Genetics and Animal Breeding, Jastrzebiec, Poland.

Tule, J. J. (2005). Effects of management system and nutrition on the performance of local chicken ecotypes at Nsukka in the derived savannah zone of Nigeria. *PhD Thesis.* Dept of Animal Science, University of Nigeria, Nsukka.

Table 1. Population Size, Effective Population Size and Change in Inbreeding Coefficient over the Three Generations of Selection

Generation	Population	Number of Individuals Male	Female	N_e	ΔF
G_0	Base Population	67	114		
	Selected	08	48	27.43	0.018
	Control	20	20		
G_1	Whole	70	123		
	Selected	11	55	36.67	0.014
	Control	20	20		
G_2	Whole	140	72		
	Selected	08	40	26.67	0.018
	Control	20	20		

G_0= Base Population, G_1= Generation One, G_2= Generation Two; N_e = Effective population size; ΔF= Change in inbreeding coefficient

Table 2. Least-square means (± SE) of the egg traits[1]

Trait[3]	Population	Generation[2] G^0	G_1	G_2
AFE(days)	Selected	159.47±1.97[a]	168.47±1.90[by]	164.78±2.40[aby]
	Control	158.40±1.13	158.94±0.10[z]	159.48±1.47[z]
BWFE(g)	Selected	962.50±23.33[ay]	1024.65±14.18[by]	1062.90±18.06[by]
	Control	880.14±16.72[z]	879.19±26.02[z]	892.10±18.85[z]
WFE(g)	Selected	30.62±0.92[ay]	31.52±0.54[by]	31.92±0.63[by]
	Control	29.44±0.37[z]	29.10±0.45[z]	29.99±0.66[z]
EW(g)	Selected	36.51±0.55[ay]	38.06±0.50[by]	38.64±0.49[by]
	Control	35.27±0.31[z]	35.73±0.39[z]	35.73±0.59[z]
EN(eggs)	Selected	33.40±1.23[a]	43.20±2.24[by]	47.18±2.36[by]
	Control	34.04±1.15	37.06±1.42[z]	37.38±2.21[z]

[ab]Means in the same row with different superscripts are significantly different (p<0.05).

[yz]Means in the same column with different superscripts are significantly different (p<0.05).

[1]LE - Light Ecotype

[2] G_0 = Base Population; G_1 = Generation One; G_2 = Generation Two

[3]AFE-Age at First Egg; BWFE-Body Weight at First Egg; WFE-Weight of First Egg, EW-Egg Weight; EN-Egg Number

Table 3. Heritability estimates of the selection criterion traits in the selected and control lines[1]

Generation	BWFE	EW	EN
G_0	0.56(0.44)	0.44(0.25)	0.28(0.20)
G_1	0.42(0.33)	0.36(0.26)	0.26(0.19)
G_2	0.41(0.41)	0.31(0.32)	0.20(0.20)

[1]Heritability estimates for each trait in the control line are shown in the parenthesis

Table 4. Genetic and phenotypic correlation of different generations in the selected and control lines

Traits[a]	G_0 Selected		Control		G_1 Selected		Control		G_2 Selected		Control	
	r_g	r_p	r_g	r_p	r_g	r_p	r_g	r_p	r_g	r_p	r_g	r_p
BW-EN	-.18	-.24	-.40	-.19	-.04	-.23	-.54	-.17	.02	-.40	-.61	-.25
BW-EW	.87	.60	.50	.49	-.07	.23	.33	.29	.13	.41	.20	.16
EW-EN	-.39	-.23	.07	-.16	-.91	-.60	-.34	-.30	.33	-.30	-.23	-.44

[a]BW= Body Weight at First Egg; EW = Average Egg Weight; EN = Egg Number

r_g = Genetic correlation; r_p= Phenotypic correlation