AJAB
Asian J Agri & Biol. 2018;6(3):396-402.
Original Research Article

Genetic parameters for body weight and egg production traits in Taiwan native chicken homozygous for the heat shock protein 70 gene

Kang Shann-Ren[1], Lin Cheng-Yung[1], Cheng Yu-Shin[2], Lin Der-Yuh[2], Huang Tsung-Ping[3], Hung Kuo-Hsiang[4], Liang Hsiao-Mei[1*]

[1]Kaohsiung Animal Propagation Station, Livestock Research Institute, Council of Agriculture, Pingtung 91247, Taiwan
[2]Livestock Research Institute, Council of Agriculture, Tainan, 71246, Taiwan
[3]Animal Propagation Department, Taiwan Sugar Corporation, Tainan 70176, Taiwan
[4]Graduate Institute of Bioresources, National Pingtung University of Science and Technology, Pingtung 91201, Taiwan

Received:
December 05, 2017
Accepted:
April 26, 2018
Published:
September 30, 2018

**Corresponding author email:*
hlliang@mail.tlri.gov.tw

Abstract
Taiwan native chicken strain (Taishu No. 7) carrying homozygous gene for heat shock protein 70 (*HSP70*) was evaluated for heritability, genetic and phenotypic correlations for body weight at birth (BW0), body weight at 16 weeks of age (BW16), egg weight at first egg (FEW), body weight at first egg (BWFE), age at first egg (AFE) and number of eggs laid up to 40 weeks of age (EN40) in female chickens. The multivariate animal model using the residual maximum likelihood procedure was applied. The estimations realized over three generations and the pedigree file was composed of 141 individuals**.** Heritability estimates of BW0, BW16, FEW, AFE, BWFE, and EN40 were 0.306, 0.763, 0.071, 0.284, 0.681, and 0.200, respectively. The body weight traits showed that the BW16 had the negative genetic correlations with BW0, AFE, and EN40 (r_g = –0.061; r_g = –0.242; r_g = –0.087), but had the positive genetic correlations with FEW and BWFE (r_g =0.419; r_g =0.945). The egg production traits showed that the EN40 had the negative genetic correlations with BW16 and AFE (r_g= –0.087; r_g = –0.195), but had the positive genetic correlation with BW0, FEW, and BWFE (r_g = 0.336; r_g = 0.039; r_g =0.182). Based on the results of this study, the BWFE could be introduced as a suitable indirect selection criteria for improving egg production because of the higher heritability and a positive genetic correlation with egg production.

Keywords: Genetic parameters, Heat shock protein 70 gene, Homozygote, Taiwan native chicken

Introduction

Many countries have utilized the native chickens as genetic resources due to their valuable characteristics of adaptability, disease resistance, meat flavour, and egg quality. In Taiwan, the consumers traditionally prefer the meat and brown eggs obtained from native chickens compared to that from broilers, and are willing to pay more for them. Nevertheless, native chicken breeds generally have lower growth and egg production characteristics (Selvaggi et al., 2015). To meet consumer demand, Taiwan farmers had improved the production performance of native chickens by crossbreeding with exotic chickens (Lee, 2006). However, the genetic variation and genetic parameters were not established, and the performance of the hybrid chicken decreased in a few generations. The Taiwan Livestock Research Institute (TLRI) has endeavoured to practice selective breeding among native chickens. The Taishu no. 7 chicken is one of the

TLRI chicken strains having red feathers and a single comb, established from the mating of indigenous chickens. The Taishu no. 7 chicken lays brown eggs (preferred by consumers in Taiwan) (Lee, 2006) and has the ability to accommodate to the summer weather in Taiwan (relative humidity of 70%, average daily temperature of 30°C). Since 2008, the Taishu no. 7 chicken has been selected to carry the homozygote of the heat shock protein 70 (*HSP70*) gene for improving the thermal tolerance. Recently, the AA genotype of the *HSP70* gene revealed higher thermal tolerance with no unfavorable impacts on growth and egg production traits (Liang et al., 2016). The Taishu no. 7 chicken carries AA genotype of the *HSP70* gene and produces about 63 eggs within 40 weeks under humid subtropical climate conditions, whereas the local red feather chicken produces about 45 eggs within the same period (Chao et al., 2005). Due to their higher egg production, the Taishu no. 7 chicken may have potential as a germplasm for improving egg production performance in indigenous chickens. Therefore, the objective of this study was to estimate genetic parameter for BW and egg production traits to find out genetic potential and the variability of the performance traits in the Taishu no. 7 chicken.

Material and Methods

Breeding and management

The study was performed at the Kaohsiung Animal Propagation Station of the TLRI. Data were obtained over three consecutive years from 2008, and three generations (G) were recorded: G_0, G_1, and G_2. The base population was hatched from 250 eggs that were obtained from the local chicken population maintained at the TLRI. Blood samples collected from 12-week-old chickens were used for genomic DNA extraction to investigate the *HSP70* gene polymorphisms using PCR-SSCP assays. Chickens were selected if they were homozygous for the *HSP70* gene. G_0 was composed of 10 males and 31 females, with superior body weight at 16 weeks of age in the base population. Pedigreed eggs were produced by artificial insemination. From each of the 10 groups of G_0, one sire and 3 to 6 hens were matched and used to constitute G_1. The same selected procedure was performed to generate G_2. The pedigree file was composed of 141 individuals. All birds lived in the same house conditions and fed the uniform diet. The diets (CP 18.2% and ME 2,947 kcal/kg for the starter; CP 15.5% and ME 2,855 kcal/kg for the grower; CP 15.5% and ME 2,751 kcal/kg for the hen) and water were provided ad libitum. The relative humidity ranged between 50% and 60% and average daily temperature ranged between 25°C and 32°C. Data were collected from female chickens. At 16 weeks of age, all females were housed in laying cages individually, and recorded egg production daily. The evaluated traits in this study were BW0, BW16, FEW, BWFE, AFE, and EN40. This study operated following the Taiwanese laws regarding animal protection, and the Kaohsiung Animal Propagation Station, TLRI approved all animal experimental procedures.

Statistical analysis

Descriptive statistics were analysed using SAS general linear model (SAS Institute, 2001). The residual maximum likelihood (REML) approach of the VCE4 computer program (Neumaier and Groeneveld, 1998) was applied for estimating the variance components and heritability of the six traits. The following model was used, as described in Poivey et al., (2001):

$$y = X\beta + Z_1 a + Z_2 p + e$$

Where y is the vector of chicken performance for the six traits measured; β is the vector of fixed effects (date of birth); a is the vector of random genetic effect with E(a) = 0; the variance of a is $A\sigma^2 a$; A is the matrix of coefficients of relationship between the chickens, and $\sigma^2 a$ is the additive genetic (co) variances; p is vector of random permanent environmental effect with E(p) = 0, and Var (p) = $I\sigma^2 p$, where I is the identity matrix; e is the random residual with E(e) = 0, Var(e) = $I\sigma^2 e$; and X, Z_1, and Z_2 are known incidence matrices connecting the performances and the effects.

Results and Discussion

Descriptive statistics of the traits

Table 1 presents the descriptive statistics of the recorded traits for body weight and egg production in the Taishu no. 7 chicken. The mean BW0 was 28 g, which is within the ranges reported on native chicken in Ethiopia, Bangladesh, and Nigeria (Dana et al., 2011; Faruque et al., 2013; Ndofor-Foleng et al., 2015). The mean BW16 was 1353 g, which is higher than that observed in other indigenous chicken breeds, such as the Horro chicken of Ethiopia and the Korean native chicken (Dana et al., 2011; Cahyadi et al., 2015). The mean FEW was 31 g, similar to the Korean native chickens (Sang et al., 2006). The average AFE was 154 days, resembled the indigenous chicken in Korea, Iran and Ethiopia, where the average age at first egg laid was in the range of 148 to 190 days (Sang et al., 2006; Dana et al., 2011; Shadparvar and Enayati, 2012; Firozjah et al., 2015). The average BWFE was 1685 g, which is higher than that of the local chickens in Nigerian and Korea, but similar to Mazandaran native chicken (Sang et al., 2006; Oleforuh-Okoleh, 2011; Shadparvar and Enayati, 2012; Firozjah et al., 2015). The average EN40 was 63 eggs, lower than observed in the Korean native chickens and Esfahan native chicken (Sang et al., 2006; Dana et al., 2011; Yousefi et al., 2013), but higher than observed in the Indian native chicken, Horro chicken, Mazandaran native chicken, (Dana et al., 2011; Haunshi et al., 2011; Firozjah et al., 2015) and Taiwan local red feather chicken produces about 45 eggs at 40 weeks of age (Chao et al., 2005). Compared with other indigenous chickens, the Taishu no. 7 chicken has a satisfied performance in EN40 trait. The AFE trait showed the lowest phenotypic variation with a coefficient of variation (CV) of 9.14%, whereas the EN40 has the highest CV value of 26.25%. Because the chickens were selected to be homozygous for the *HSP70* gene in this study, the lower CV values of traits were expected. Furthermore, the breed was developed to have similar characteristics. Due to high CV value of EN40 trait, more data will be necessary to estimate for finding out the genetic variability of egg production trait (Mulder et al., 2007).

Heritabilities

The estimations of heritabilities, genetic and phenotypic correlations for body weight and egg production traits are shown in Table 2. The heritability of BW0 in this study was 0.306, higher than the estimated value (0.13) by Shadparvar and Enayati (2012), similar to that reported in Mazandaran native chickens (0.33), Horro chickens of Ethiopia (0.40) and Esfahan native (0.42) (Dana et al., 2011; Yousefi et al., 2013; Firozjah et al., 2015). Yousefi et al., (2013) explained that the higher heritability of body weight at birth was attributed to excluding the maternal and permanent environmental effects in statistical model, this supports our result of the heritability estimates for BW0. The heritability of BW16 in the present study was 0.763, higher than the value (0.31) reported by Cahyadi et al., (2015), but similar to high heritability values in Nigerian local chicken (0.72) (Rotimi et al., 2016). The heritability estimations of the egg production traits showed that the heritability of FEW was 0.071, lower than the values (0.12 and 0.20) reported in the Mazandaran native chicken (Shadparvar and Enayati, 2012; Firozjah et al., 2015). The heritability of AFE was 0.284, lower than the value (0.34) reported by Shadparvar and Enayati (2012), but similar to that reported in Iranian native fowls (0.27) (Ghazikhani et al., 2007), and in Korean native chickens (0.12 to 0.32) (Sang et al., 2006). The heritability of BWFE was 0.681, similar to that of in Nigerian local chicken (0.56) (Oleforuh-Okoleh et al., 2011); higher than the range (0.39 to 0.43) in four strains of Korean native chickens reported by Sang et al., (2006). The EN40 heritability was 0.200, lower than the range (0.24 to 0.36) reported in four strains of Korean native chickens (Sang et al., 2006), but higher than the values reported in Iranian native fowls (0.14) and in Mazandaran native chickens (0.15) (Ghorbani et al., 2012; Shadparvar and Enayati, 2012). Compared with other indigenous chickens, Our results showed that the Taishu no. 7 chicken has relatively a high heritability of BW16, suggesting that selection at 16 weeks of age may be effective in improving body weight. The comparatively lower heritability estimates for egg production of the native chickens in this study may be attributed to the heritability of egg production, which is controlled by many genes. Selection for this characteristic in the homozygous native chicken generally shows slow progress. This result was confirmed by previous reports showing that native chickens are poor egg layers (Chao et al., 2005; Dana et al., 2011).

Genetic and phenotypic correlations

The BW0 had negative genetic correlations with BW16, FEW, and AFE (r_g = –0.061; r_g = –0.313; r_g = –0.509), but had positive genetic correlations with BWFE and EN40 (r_g = 0.191; r_g = 0.336). In the present study, the BW0 had a low and negative genetic correlation with BW16 (r_g = –0.061) was not in consonance with the previous reports reported that the phenotypic and genetic correlations between body weights at various ages were positive in various chickens (Sang et al., 2006; Dana et al., 2011; Momoh et al., 2014). However, the growth of bird is generally nonlinear (Zhao et al., 2015), other researches suggesting that more efficient selection would be realized on the growth curve parameters (Mignon-Grasteau et al., 1999; N'dri et al., 2006). Manjula et al. (2017) estimated the genetic parameters for body weight gain and growth curve parameter traits in the

Korean native chicken and obtained that the genetic correlation between the weight gain from birth to 2 weeks of age and weight gain from 14 to 16 weeks of age was negative (r_g = –0.140); this supports the result of the present study.

The genetic correlations of BW0 with FEW and with AFE were negative, suggesting that the heavier chick at birth tend to have lighter egg weight at first egg and earlier age of laying. However, the phenotypic correlations between these traits were positive, resulted in heavier chick at birth had a heavier egg weight at first egg and later age of laying. It suggested that the environments sufficiently affecting these traits, caused the genetic correlations be opposite observed phenotypic correlations. The positive genetic correlation between BW0 and BWFE was 0.191, lower than the value (r_g =0.89) reported in the Nigerian indigenous chick (Udoh and Jaja, 2014), but similar to that reported (r_g = 0.25) in Mazandaran native breeder hens (Shadparvar and Enayati, 2012). In the present study, the low positive genetic correlation between BW0 and BWFE might be caused by the nonlinear growth of chicken. Therefore, studying on the growth curve for Taishu no. 7 chicken is required in the future work. Our result of the positive genetic correlation between BW0 and EN40 was different from that observed by Yousefi et al. (2013), reported that the BW0 of Nigerian indigenous chick had a negative correlation coefficient (r_g = –0.04) with the number of eggs, but similar to that reported in Mazandaran native breeder hens (r_g = 0.03) and Horro indigenous chickens (r_g = 0.42) (Dana et al., 2011; Shadparvar and Enayati, 2012).

The BW16 has been used to estimate if the hens have attained a well-developed body frame that is suitable for egg production. In the present study, the estimated genetic correlation between BW16 and FEW (r_g = 0.419) was higher than the genetic correlation (r_g = 0.23) between body weight at 12 weeks of age and FEW in Mazandaran native breeder hens (Shadparvar and Enayati, 2012). The genetic and phenotypic correlations between BW16 and AFE were negative and moderate (r_g = –0.242 and r_p = –0.476) respectively, suggesting that these two traits are restricted by the levels of genetic correlation. BW16 and BWFE have a high genetic correlation (r_g = 0.945), because both BW16 and BWFE participate in the assessment of sexual maturity. However, BW16 and BWFE have a negative and moderate phenotypic correlation (r_p = –0.468); this indicates that the characteristics of these traits were influenced by environmental effects. BW16 and EN40 had a low genetic (r_g = –0.087) and phenotypic (r_p = –0.048) correlations, implying that these two traits were dominated by disparate and non-linked genetic loci. It might explain the reason that selected chickens with superior BW16 had no significant effect on egg production in the present study. On the other hand, BW16 had the highest value of heritability (h = 0.763) among the other growth traits measured, accordingly, the chickens were selected at 16 weeks of age could be the suitable approach to develop meat breeds in Taishu no. 7 chicken.

The genetic correlation between FEW and AFE (r_g = 0.727) was higher than the value (r_g = 0.39) in Mazandaran native breeder hens (Shadparvar and Enayati, 2012), but similar to the observation by Agaviezor et al., (2011). Consistently, the phenotypic correlation between FEW and AFE was positive (r_p =0.529). The genetic and phenotypic correlations between FEW and AFE were both positive, indicated that chickens were selected for heavier FEW would result in later egg production. The genetic and phenotypic correlations between FEW and BWFE were positive (r_g = 0.430 and r_p = 0.592) respectively, implied that selection for heavier egg weight at first egg would result in increase chicken body weight at first egg. This result was similar to that reported in Mazandaran native breeder hens (r_g = 0.54 and r_p = 0.21) (Shadparvar and Enayati, 2012). The FEW had a low and positive genetic correlation with EN40 (r_g = 0.039) was not in consonance with the previous reports reported that genetic correlations with FEW and EN40 were negative in Korean native chicken (r_g = -0.05) and Mazandaran native breeder hens (r_g = -0.66) (Sang et al., 2006; Shadparvar and Enayati, 2012), but similar to that reported in three laying lines of quails (r_g = 0.09 to 0.58) (Hidalgo et al., 2011). The low and positive genetic correlation of FEW and EN40 in Taishu no. 7 chicken, indicated that the selection on FEW traits has the positive impact on EN40, but to a lesser degree.

The early sexual maturity consequently will result in the increment of total egg number. Therefore, the chicken has acted to reduce the time to sexual maturation. The AFE had the negative genetic correlations with BWFE (r_g = –0.300) and EN40 (r_g = –0.195) respectively, indicated that selection of early sexual maturity would result in heavier BWFE and increased egg production.

The BWFE had a low and positive genetic correlation with EN40 (r_g = 0.182), indicating that BWFE had the lesser contribution to the variation in the number of eggs produced. However, the BWFE relatively had the highest heritability ($h^2 = 0.681$) among the other traits measured in this study and would be suitable as an indirect selection criteria for improving egg production.

Table 1. The recorded traits of the Taishu no. 7 female chickens used in this study, showing the number of observations (N), mean, standard deviation (SD), coefficient of variation (CV), and minimum and maximum values[1].

Traits	N	Mean	SD	CV (%)	Minimum	Maximum
BW0 (g)	90	28	3.1	10.81	20	37
BW16 (g)	90	1353	188.0	13.89	1028	1883
FEW (g)	90	31	6.1	19.57	13	51
AFE (day)	90	154	14.1	9.14	126	201
BWFE (g)	90	1685	243.3	14.44	1226	2386
EN40 (eggs)	90	63	16.6	26.25	17	103

[1]BW0 = body weight at birth; BW16 = body weight at 16 weeks of age; FEW = egg weight at first egg; AFE = age at first egg; BWFE = body weight at first egg; EN40 = total number of eggs laid up to 40 weeks of age.

Table 2. Heritability (diagonal), genetic (above the diagonal) and phenotypic (below the diagonal) correlations between different body weights[1] and egg production traits[2] in Taishu no. 7 female chickens

Traits	BW0	BW16	FEW	AFE	BWFE	EN40
BW0	0.306	–0.061	–0.313	–0.509	0.191	0.336
BW16	–0.023	0.763	0.419	–0.242	0.945	–0.087
FEW	0.118	–0.005	0.071	0.727	0.430	0.039
AFE	0.122	–0.476**	0.529**	0.284	–0.300	–0.195
BWFE	0.061	–0.468**	0.592**	0.913**	0.681	0.182
EN40	–0.069	–0.048	–0.038	0.536**	0.424**	0.200

[1]BW0 = body weight at birth; BW16 = body weight at 16 weeks of age
[2]FEW = egg weight at first egg; AFE = age at first egg; BWFE = body weight at first egg;
EN40 = total number of eggs laid up to 40 weeks of age
**Significant ($p < 0.01$)

Conclusion

In the present study, we investigated the suitable selection criteria to enhance the productivity of the growth and egg production in native chicken production system. Results estimated that both BW16 and BWFE have high heritabilities, showed these traits could be used as the direct selection criteria for improving growth performance. Although BW16 has high heritability, the genetic correlation with EN40 was negative. On the other hand, the BWFE had a higher heritability and a positive genetic correlation with egg production, and is introduced as a suitable indirect selection criterion for improving egg production. This study established the foundational genetic parameter in Taishu no. 7 chicken; however, further work using a larger data set is recommended to confirm the current findings.

Acknowledgement

The authors sincerely acknowledge the financial support from the Kaohsiung Animal Propagation Station of TLRI. Contribution No. 2625 from TLRI. The authors express gratitude to Mr. Lin Mao-Chuan for raising and handling the chickens.

References

Agaviezor BO, Ajayi FO, Adebambo BO and Gunn HH, 2011. Nigeria indigenous vs exotic hens: the correlation factor in body weight and laying performance. Afr. Res. Rev. 5(1): 405-413.
Cahyadi M, Park HB, Seo DW, Jin S, Choi N, Kang-Heo N, Kang BS, Jo C and Lee JH, 2015. Genetic parameters for growth-related traits in Korean native chicken. Korean J. Poult. Sci. 42(4): 285-289.

Chao CH, Lin MJ, Lai YL, Su ML, Ho YC, Chen CF and Lee YP, 2005. The egg production of commercial breeders of Taiwan Country chicken. J. Chin. Soc. Anim. Sci. 34(3): 151-161.

Dana N, Waaij-vander EH and Arendonk-van JAM, 2011. Genetic and phenotypic parameter estimates for body weights and egg production in Horro chicken of Ethiopia. Trop. Anim. Health Prod. 43(1): 21-28.

Faruque S, Islam MS, Afroz MA and Rahman MM, 2013. Evaluation of the performance of native chicken and estimation of heritability for body weight. J. Bangladesh Acad. Sci. 37(1): 93-101.

Firozjah NG, Atashi H and Zare A, 2015. Estimation of genetic parameters for economic traits in Mazandaran native chickens. J. Anim. Poult. Sci. 4(2): 20-26.

Ghazikhani SA, Nejati A and Mehrabani H, 2007. Animal model estimation of parameters for most important economic traits in Iranian native fowls. Pak. J. Biol. Sci. 10(16): 2787-2789.

Ghorbani SH, Kamali MA, Abbasi MA and Ghafouri-Kesbi F, 2012. Estimation of maternal effects on some economic traits of North Iranian native fowls using different models. J. Agric. Sci. Tech. 14(1): 95-103.

Haunshi S, Niranjan M, Shanmugam M, Padhi MK, Reddy MR, Sunitha R, Rajkumar U and Panda AK, 2011. Characterization of two Indian native chicken breeds for production, egg and semen quality, and welfare traits. Poult. Sci. 90(2): 314-320.

Hidalgo AMI, Martins EN, Santos dos AL, Quadros de TCO, Ton APS and Teixeira R, 2011. Genetic characterization of egg weight, egg production and age at first egg in quails. R. Bras. Zootec. 40(1): 95-99.

Lee YP, 2006. Taiwan country chicken: a slow growth breed for eating quality, pp. 121-132. In C. W Liao, B. L Shih, M. L. Lee, A. L. Hsu and Y. S. Cheng, Proceedings, Symposium: Scientific Cooperation in Agriculture between Council of Agriculture (Taiwan, R.O.C.) and Institut National de la Recherche Agronomique (France), 7-10 November 2006, Tainan, Taiwan. Technical Bulletin of Livestock Research Institute.

Liang HM, Lin DY, Hsuuw YD, Huang TP, Chang HL, Lin CY, Wu HH and Hung KH, 2016. Association of heat shock protein 70 gene polymorphisms with acute thermal tolerance, growth, and egg production traits of native chickens in Taiwan. Arch. Anim. Breed. 59(2): 173-181.

Manjula P, Hee-Bok P, Dongwon S, Nuri C, Shil J, Sung JA, Kang NH, Bo SK and Lee JH, 2018. Estimation of heritability and genetic correlation of body weight gain and growth curve parameters in Korean native chicken. Asian Aust J. Anim. Sci. 31(1):26-31

Mignon-Grasteau S, Beaumont C, Bihan–Duval EL, Poivey JP, Rochambeau H and Ricard FH, 1999. Genetic parameters of growth curve parameters in male and female chickens. Br. Poult. Sci. 40(1): 44-51.

Momoh OM, Gambo D and Dim NI, 2014. Genetic parameters of growth, body, and egg traits in Japanese quails (Cotournix cotournix japonica) reared in southern guinea savannah of Nigeria. J. Appl. Biol. Sci. 79: 6947-6954.

Mulder HA, Bijma P and Hill WG, 2007. Prediction of breeding values and selection responses with genetic heterogeneity of environmental variance. Genetics 175(4): 1895-1910.

N'dri AL, Mignon-Grasteau S, Sellier N, Tixier-Boichard M and Beaumont C, 2006. Genetic relationships between feed conversion ratio, growth curve and body composition in slow-growing chickens. Br. Poult. Sci. 47(3): 273-280.

Ndofor-Foleng HM, Oleforuh-Okoleh V, Musongong GA, Ohageni J and Duru UE, 2015. Evaluation of growth and reproductive traits of Nigerian local chicken and exotic chicken. Indian J. Anim. Res. 49(2): 155-160.

Neumaier A and Groeneveld E, 1998. Restricted maximum likelihood of covariances in sparse linear models. Genet. Sel. Evol. 30(1): 13-26.

Oleforuh-Okoleh VU, 2011. Estimation of genetic parameters and selection for egg production traits in a Nigerian local chicken ecotype. J. Agric. Biol. Sci. 6(12): 54-57.

Poivey JP, Cheng YS, Rouvier R, Tai C, Wang CT and Liu HL, 2001. Genetic parameters of reproductive traits in Brown Tsaiya ducks artificially inseminated with semen from Muscovy drakes. Poult. Sci. 80(6): 703-709.

Rotimi EA, Egahi JO and Momoh OM, 2016. Heritability estimates for growth traits in the Nigerian local chicken. J. Appl. Life Sci. Int. 6(2): 1-4.

Sang BD, Hong SK, Kim HK, Choi CH, Kim SD, Cho YM, Sang BC, Lee JH, Jeon GJ and Lee HK, 2006. Estimation of genetic parameters for economic traits in Korean native chickens. Asian Aust. J. Anim. Sci. 19(3): 319-323.

SAS Institute, 2001. PROC user's manual, version 6th ed. SAS Institute, Cary, NC.

Selvaggi M, Laudadio V, Dario C and Tufarelli V, 2015. Modelling growth curves in a nondescript Italian chicken breed: An opportunity to improve genetic and feeding strategies. J. Poult. Sci. 52(4): 288-294.

Shadparvar A and Enayati B, 2012. Genetic parameters for body weight and laying traits in Mazandaran native breeder hens. Iran. J. Appl. Anim. Sci. 2(3): 251-256.

Udoh UH and Jaja JSA, 2014. Prediction of egg production traits in local chickens using hatch weights. Nigerian J. Agric. Food Environ. 10(2): 87-90.

Yousefi ZA, Alijani S, Mohammadi H, Rafat A and Daghigh KH, 2013. Estimation of genetic parameters for productive and reproductive traits in Esfahan native chickens. J. Livest. Sci. Technol. 1(2): 34-38.

Zhao Z, Li S, Huang H, Li C, Wang Q and Xue L, 2015. Comparative study on growth and developmental model of indigenous chicken breeds in China. Open J. Anim. Sci. 5(2): 219-223.